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HOOKE'S THEORY OF COMBUSTION.

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Much of the work of Robert Hooke on the subject of combustion—more particularly the theoretical implications—is to be found in the *Micrographia*, printed in 1664, but not published until 1665. Hooke presented his theory of combustion quite clearly, and further amplified it in his *Lampas*, 1677, and *Cutlerian Lectures*, 1679, but he gave an indifferent and scanty account of the experiments that he had made to demonstrate the truth of his ideas. It is a matter for regret that he did not carry out his expressed intention of writing a complete and separate treatise on this subject, more especially as his theory was essentially based on observations. However, Birch's *History of the Royal Society*, London, 1756–7, which is really nothing more than a copy of the Society's *Journal Book* for the period 1661–87, fills a considerable gap in this respect, and shows that Hooke experienced great difficulty in overcoming the reluctance with which the other members of the Society admitted the strength of his evidence.

How far must one attribute Hooke's failure to impress his views to the lowliness of his social position as compared with that of the rest of the members? How far to the extreme simplicity of his conceptions in comparison with the

mystery and tangle of other chemical (or alchemical) ideas? And how far to the slowness with which news and ideas gained currency in the seventeenth century? All these factors undoubtedly contributed, and, as is shown here, it was necessary after some years had elapsed to verify a statement that a fundamental experiment had already been carried out successfully.

The Royal Society was never particularly gracious towards Hooke, and the nature of the dedication upon which the Fellows insisted when he proposed publishing his *Micrographia* provides evidence of their attitude towards his work, suggesting that there might possibly be some foundation in fact for his ideas, but that, failing this, the Society had no desire to be involved in any responsibility for them. Hooke sensed this antagonism and attributed it to the Secretary, Oldenburg. He expressed his opinions rather forcibly in his Diary, where we read under the date Mon. Nov. 8th, 1675, " Saw the lying Dog Oldenburg's transactions ', and on Thurs. Nov. 11th, ' . . . . Found that Oldenburg had not entered Experiment about the colours of the Selenites shew'd in July last, nor many other things ' (*The Diary of Robert Hooke*, 1672–80, Ed. H. W. Robinson and W. Adams, London, 1935). Again on June 3rd he wrote, ' Oldenburg a raskall for not registering things brought into the Society, to wit that of the water engine with small pipes '. On Thurs. June 10th 1775, he said ' I reproved Oldenburg for not registering Experiments. Brouncker took his part.' Hooke obviously had a hard struggle to win recognition of his work, but as we reach the year 1687, where Birch's *History* closes, we find others joining him in his desire to know more about the nature of combustion and its relation to the atmosphere. In this connection none was more helpful than Papin.

An attempt will be made to show how, often at consecutive meetings of the Society, the same experiment and its associated ideas were forced upon the Fellows until some degree of interest, if not of acceptance, could be attained. A possible exception to this attitude may be found in the case of Mayow, whose ideas had much in common with those of Hooke. Although this medico-chemist has probably been overrated by later writers (Patterson, *Isis*, 1931), and although much of his work is borrowed from contemporaries, yet he certainly was appreciated by Hooke as sympathetic to his theory of combustion. Mayow's nomination to the Society was proposed by Hooke on November 30th, 1676, and his *Tractatus Quinque Medico-Physici* had already been published in 1674. Unfortunately, Mayow died a few months after being admitted, and Hooke lost a valuable ally.

The Original Theory.

In the *Micrographia* Hooke summed up his theory of the atmosphere and combustion in the following manner :—

> ' First, *that the air* in which we live, move, and breath, and which encompasses very many, and cherishes most bodies it encompasses, that

this Air is the *menstruum*, or universal dissolvent of all *sulphureous* bodies.

'Secondly, *that this action* it performs not, till the body be first sufficiently heated, as we find requisite also to the dissolution of many other bodies by several other *menstruums*.

'Thirdly, *that this action* of dissolution, produces or generates a very great heat, and that which we call Fire; and this is common also to many dissolutions of other bodies, made by *menstruums*, of which I could give multitudes of Instances.

'Fourthly, *that this action* is perform'd with so great a violence, and does so minutely act, and rapidly agitate the smallest parts of the *combustible* matter, that it produces in the *diaphanous medium* of the Air, the action or pulse of light, which what it is, I have else where already shewn.

'Fifthly, that the *dissolution* of sulphureous bodies is made by a substance inherent, and mixt with the Air, that is like, if not the very same, with that which is fixt in *Salt-petre*, which by multitudes of Experiments that may be made with *Saltpetre*, will, I think, most evidently be demonstrated.

. . . . . .

'Therefore twelthly, it seems reasonable to think that there is no such thing as an Element of Fire that should attract or draw up the flame, or towards which the flame should endeavour to ascend out of a desire or appetite of uniting with that as its *Homogeneal* primitive and generating Element; but that that shining transient body which we call *Flame*, is nothing else but a mixture of Air, and volatile sulphureous parts of dissoluble or combustible bodies, which are acting upon each other whilst they ascend, that is, flame seems to be a mixture of Air, and the combustible volatile parts of any body, which parts the encompassing Air does dissolve or work upon, which action, as it does intend the heat of the *aerial* parts of the dissolvent, so does it thereby further rarifie those parts that are acting, or that are very neer them, whereby they growing much lighter than the heavie parts of that *Menstruum* that are more remote, are thereby protruded and driven upwards; . . . .

'This *Hypothesis* I have endeavoured to raise from an Infinite of Observations and Experiments, the process of which would be far too long to be inserted here, and will perhaps another time afford matter copious enough for a much larger Discourse . . . .

'[Speaking of the air] But being once well understood, it will, I doubt not, inable a man to render an intelligible, nay probable, if not the true reason of all the *Phænomena* of Fire . . . .' (*Micrographia*, London, 1665, pp. 103–5.)

Hooke also dealt with the subject of calcination, linking it up with combustion in the following way:—

'That all Metals (excepting Gold and Silver, which do not so much with the bare fire, unless assisted by other saline Bodies) do more or less *vitrifie* by the strength of fire, that is, are corroded by a saline Substance, which I elsewhere shew to be the true cause of fire; and are thereby, as by several other *Menstruums*, converted into *Scoria*; And this is called, *calcining* of them, by Chimists . . . .

'. . . . That most kind of *Vitrifications* or *Calcinations* are made by Salts, uniting and incorporating with the metalline Particles. Nor do I know any one *calcination* wherein a *Saline* body may not, with very great probability, be said to be an agent or coadjutor.' (*Ibid.*, p. 51.)

Inquiries into the Nature of the Air.

The first suggestions (*Birch*, i, 202[1]) laid before the Society for an investigation of the atmosphere appear to have been made by Hooke, who on February 25th, 1663, brought in a ' scheme of inquiries concerning the air ', in response to an order to do so made at the previous meeting of the Society. He was commissioned to include in it such experiments as had already been made on the subject, and also any further ideas that might occur to him.

According to Hooke the requirements for such a scheme were, firstly a search after and collection of all reliable observations and experiments that had been made on the subject, and secondly, further careful and repeated experiments to test the truth of these records and to give support or opposition to any hypotheses that may have been put forward. These experiments were to be designed in reference to three main questions, namely :—Of what substances were the particles of air composed ? [2] What was the quantity or extent of the air ? And what was the nature of its spring or motion ? The last question would include a consideration of the bodies with which air readily united and of those with which it did not, and the reasons for this difference.

The Burning of Antimony.

The first mention of the subject of calcination before the Royal Society occurred in June, 1664, when Sir Robert Moray requested that the statement made by some chemists that antimony increased in weight when heated should be tested, Dr. Goddard being commissioned to carry out the experiment (*Birch*, i, 445). It is somewhat unfortunate that antimony should have been chosen (as is now known, the volatilization of the oxide is responsible for the failure of the experiment), but it was a metal much used in this connection, probably on account of its easy and obvious calcination. Jean Rey's *Essays* (Bazas, 1630) had quoted its use by Poppius, whose work appeared about 1625 (*Basilici Antimonii*), but Rey himself had paid more attention to tin and lead, quoting Poppius's observation on antimony as a confirmatory crucial experiment. It is to Goddard's credit that he found that, so far from increasing in weight, the metal actually showed a decrease from twelve grains to between three and four (*Birch*, i, 452). Boyle asserted that he had made a similar observation, but Le Febure had told him that the antimony ' had not been calcined enough to reduce it to a fixed salt fit for the imbibing of air. Le Febure

[1] References to Birch's *History of the Royal Society* are given thus, the first number representing the volume and the second the page.

[2] ' Whether infinitely fluid, or definitely solid ? If solid, whether the interstice between them be vacuity, or replenished with some more subtile and fluid body.'

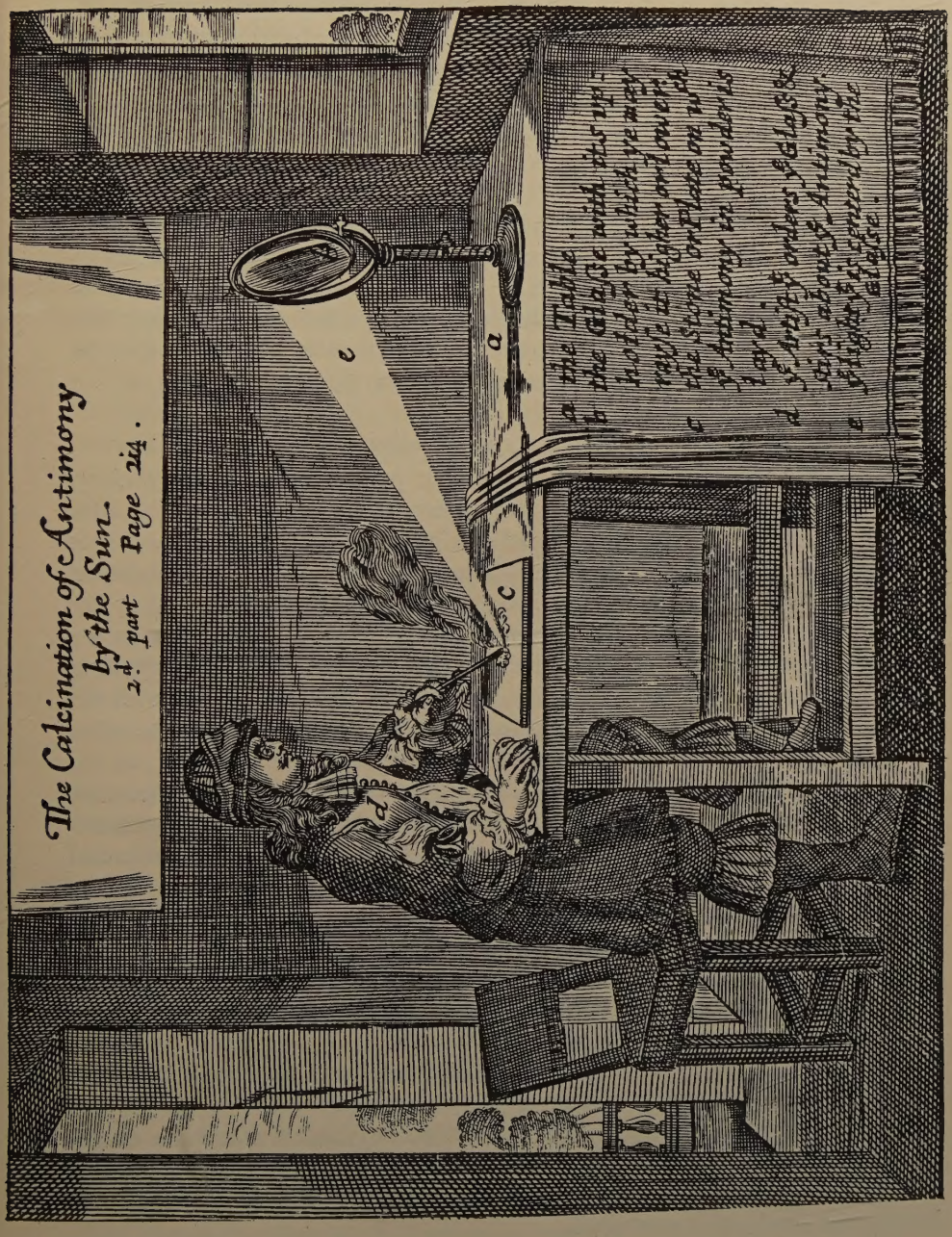


Fig. 1.—The Solar Calcination of Antimony. (From *A Compleat Body of Chymistry* by Nicasius le Feburc. Rendred into English by P. D. C. Esq. London, 1670.)

in his *Traicté de la Chimie* says that in order to obtain an increase in weight from twelve to fifteen grains it was essential repeatedly to heat the powdered metal on a marble slab by means of the sun's heat directed with a mirror. This increase, he said, occurred in spite of the vaporization (Le Febure, *Traicté de la Chymie*, vol. ii, p. 996). Mayow had a similar idea that the increase was due to some particular property of the sun's rays, the antimony growing heavier owing to 'nitro-aerial and igneous particles fixed in it during calcination' (*Tractatus Quinque Medico-Physici*, Oxford, 1674; Alembic Club Reprint, pp. 20, 21).

The investigation of this matter, however, so far as the Society was concerned, appears to have been fruitless; for it was not until December, 1679, after Mayow had described his results in this experiment in the *Tractatus Quinque*, that Henshaw stated that the increase was a fact and that Boyle had found likewise. On this occasion, however, Hooke definitely stated that he had several times found a decrease in weight (*Birch*, iii, 512).

Air Necessary for Burning.

In January, 1665, Hooke, in an experiment performed before the Society, placed a piece of burning charcoal under a glass vessel, and showed that after a very short time the burning ceased but that, on admitting more air, it recommenced (*Birch*, ii, 2). He went on to show that even if a combustible body were kept red-hot, it would not "waste away" unless it had a free supply of air, whereupon Boyle proposed that a wind be caused by means of bellows, but with the inlet of the bellows closed so that only the original air in the receiver was agitated (*Birch*, ii, 7); and Goddard further suggested the repetition of Lord Bacon's experiment of enclosing a piece of wood in a cylindrical vessel of iron and heating it strongly in a fire. Consequently, at the following meeting of the Society Hooke carried out three experiments with the following results. Firstly, a piece of sulphur, sealed in a pipe and made red-hot, did not burn at all until air was admitted; secondly, charcoal did not burn when so enclosed and heated; and thirdly, some of the same substance covered with sand in a crucible and heated strongly for some hours was found to be practically unchanged. It was urged that steam and other substances from the bodies were responsible for preventing burning in such cases, and therefore Hooke proposed to arrange for the withdrawal of the air so 'superonerated' (*Birch*, ii, 4).

It was, by the way, at this meeting that Hooke was appointed curator to the Society with a temporary salary of £30 per annum.

A week later Boyle's suggestion was carried out, and it was quite clearly shown that the agitation of the enclosed air was not of itself capable of sustaining the burning, but that immediately fresh air was admitted *via* the bellows the combustion re-started.

Viscount Brouncker, the President, expressed the satisfaction of the Society that this point had been proved, but desired a further experiment to show that 'exhalations' from the burning had not filled the pores of the air, which

was on that account unable to take up any more ; and Sir J. Moray enquired whether the compression of the air might not be responsible for the extinction of the fire (*Birch*, ii, 8). Hooke anticipatingly answered that since rarefied air was found to cause burning bodies to go out earlier, condensed air would undoubtedly keep them burning longer ; and this statement he substantiated a week later by showing that a lamp burned for only three minutes in a receiver of ordinary air but for fifteen minutes in the same receiver of compressed air (*Birch*, ii, 10).

The possibility of a second substance being fired after the first had been extinguished in a closed vessel was suggested by Boyle, and a piece of red-hot iron was allowed to fall on some unburnt charcoal after a dish of similar material had ceased to burn. It was found, of course, that the red-hot iron had no effect upon the powder (*Birch*, ii, 12).

At the same meeting, at the suggestion of Dr. Ent, a bird was included in the receiver with the burning substance ; it was shown that the bird began to die as the charcoal went out but revived on being let into the open air.

Other Supporters of Combustion.

The next step was again taken by Hooke, who showed that nitre revived a burning substance in the same way as air did, Boyle here asserting that gunpowder burned quite well in an exhausted receiver—a statement that was confirmed by Hooke the same day. Boyle further proposed to put sulphur on a red-hot iron crucible in an exhausted receiver to see whether it would flame, and to try to burn alcohol and other substances *in vacuo* in order to see whether the presence or absence of air made any difference to the products (*Birch*, ii, 17). Unfortunately he was here confusing mere heating with burning, since he compared the products obtained with those produced in common distillations. However, an interesting allusion is made to the large quantities of a ' volatile salt ' (ammonium salts) found in soot, Boyle pointing out that no such salt was formed in the absence of air.

On March 1st, 1665, some saltpetre was put into a red-hot crucible in the exhausted receiver, and sulphur was allowed to fall upon it. The sulphur was seen to ' flame as freely, as if it had been in the open air ' (*Birch*, ii, 19). This, coupled with a previous experiment made by Hooke (*Birch*, ii, 15), in which tin had been similarly heated, produced the inference ' that there are bodies combustible, that are not sulphureous ' for ' it was not known, that any sulphur ever was extracted out of tin ' (*Birch*, ii, 20).

Parallel between Combustion and Respiration.

It was not until July, 1667 (two years later), that the problem of air was again discussed. It arose in connection with the question as to what quality it was of the air that made it fit for respiration. Hooke was of the opinion that there was ' a kind of nitrous quality in the air, which makes the refreshment necessary to life, which being spent or intangled, the air becomes unfit '.

Further, he showed that he very closely connected the processes of burning and breathing by recounting the experiment made more than two years previously, which showed that the air in which a body has burned will no longer support combustion, even if it be agitated by bellows; it was necessary, he held, for the 'grosser parts thereof' to be 'precipitated' before further

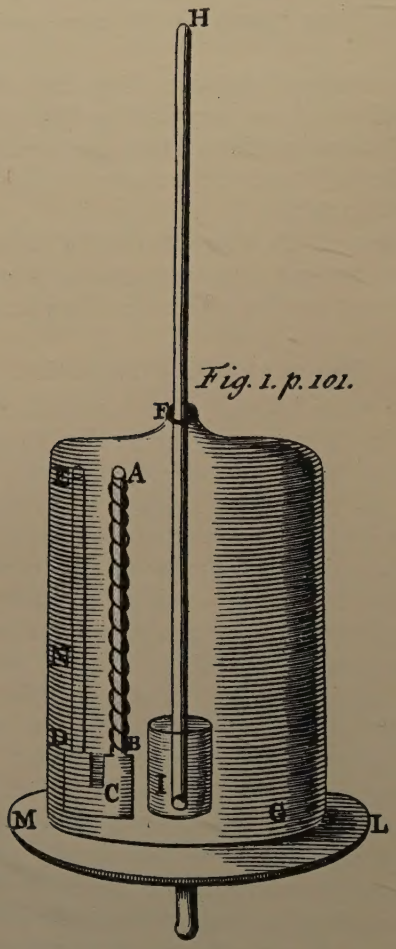


Fig. 1. p. 101.

FIG. 2.—Mercurial gauge as used in Hooke's experiments. ABCDE represents the gauge. The end A is open, E is sealed, BCD contains mercury. (From *The Works of the Honourable Robert Boyle*, London, 1744, iv, fig. 1, p. 101.)

combustion could occur (a further reference to the effects of the products of combustion in preventing further burning) (*Birch*, ii, 184).

This discussion led to a proposal to build a receiver that would be large enough to hold a man—a project which was estimated by Hooke as curator

to cost about five pounds. Actually, it was not until two years had gone by that Hooke eventually reported to the Society that he had been in the receiver for a quarter of an hour and had not suffered any discomfort; but he was of the opinion that a man could not stand an exhaustion of more than a quarter of the air.

The description of this particular instrument, in Hooke's own words (*Birch*, ii, 467), was that 'it consisted of two tuns, one included in the other; the one to hold a man, the other filled with water to cover the former, thereby to keep it stanch; with tops to put on with cement; or to take off; one of them having a gage, to see to what degree the air is rarefied; as also a cock to be turned by the person, who sits in the vessel, according as occasion shall require, &c.'

It was resolved that as many as possible should attend a demonstration on these lines; some animals and lighted candles were also to be taken in with the operator.

The report of the experiment states that when a quarter of the air had been evacuated Hooke was able to remain in it somewhat more than a period of fifteen minutes without any other inconvenience than a pain in his ears and a sensation of deafness, both of which effects disappeared after he emerged and walked up and down for a short while. A candle taken into the vessel had gone out long before he felt these effects (*Birch*, ii, 472).

Brouncker objected that, although Hooke had been enclosed for a quarter of an hour, fresh supplies of air had been frequently admitted, and that the absence of a quarter of the air had only endured for a short time.

In the meantime Hooke had tried the experiment of placing a bird in the receiver under two conditions—firstly, with ordinary air, and secondly, with compressed air ('compressed .... in the space of eleven minutes by the gage') (fig. 2). He found that the bird remained in good health much longer under the latter condition than under the former. It is an interesting comment on the lack of importance attached to these experiments by the remaining members that it was necessary for Hooke to have verified a statement made at this meeting that he had shown a similar result for a burning candle on January 25th, 1664—four years previously (*Birch*, ii, 304).

Other Combinations with the Air.

On July 16th, 1668, Hooke expressed his opinion that, when alkalies were exposed to the air, they combined with the volatile salt in the air and converted it into nitre. Coxe, on the contrary, suggested that the air 'extricated' that nitrous substance from the alkalies; whereupon, in a truly scientific way, it was proposed that the best method to decide the point was to weigh some oil of tartar before and after exposure to the air. Unfortunately this does not appear to have been carried out, and once again the discussion was fruitless (*Birch*, ii, 307).

Products of Combustion of a Candle—Hooke's Theory.

Returning to the problem of combustion, one of his main interests, Hooke carried out an experiment demonstrating that an upward stream is evolved when a candle burns, and that, just as the flame itself was produced by the action of air on the heated part of the candle, so this stream was due to combination ('composition') between the air and the gases given off by the candle when so heated (*Birch*, iii, 15 *et seq.*).

It is strange that in the next reference to this experiment the word 'steam' appears instead of 'stream', and the experiment is quoted as showing that there was steam formed by the candle apart from the smoke and the air in the neighbourhood. The experiment was repeated at the next meeting on February 29th, 1672, and, proving satisfactory, was ordered to be the subject of a written account by Hooke (*Birch*, iii, 16).

A fortnight later this account was produced before the Society, and Hooke said it was designed to prove that the substance of the candle was dissolved by the air and that the greatest part of it was reduced to a fluid having the form of air. It appears that the alteration to steam arose through Hooke's written report; for he tells how he looked through a magnifying glass at a burning candle and observed a rising stream of liquor from the wick in a continual current, which he described as a 'jet d'eau' (*Birch*, iii, 19; *O.R.*[3], iv, 126). He supposed this 'jet d'eau' to be a mixture of the air with the parts of the candle—the air being the universal solvent of all sulphureous bodies, and the solution being almost always accompanied by heat and light. He went on to explain that the gases so produced rose on account of their rarefaction, the heat of the flame making them lighter than the surrounding air. Hooke had therefore concluded that the products of combustion of a candle were gaseous and consisted of the candle itself combined with (or dissolved in) the air.

The reception of this conclusion, now thought to be so near the truth, was only lukewarm, and the subject of the products of combustion was not pursued.

Decrease of Air by Burning

It was again Hooke who suggested (November 1672) that experiments be devised to discover whether air was consumed or increased by burning (*Birch*, iii, 61 *et seq.*). Boyle had shown[4] that air which had become unfit for respiration did not lose any of its pressure, animals being placed in the receiver and a pressure gauge included. In these discussions Boyle seems to have missed the point at which Hooke was driving; for he proceeded to suggest irrelevant experiments for producing gases by other means than burning. However, Hooke did carry out his suggestion, and after one failure came to the conclusion that there was neither increase nor decrease of air by burning[5].

[3] *Original Register* of the Royal Society.

[4] *Philosophical Transactions*, v, 2046.

[5] This result was, of course, correct, for carbon+1 vol. oxygen produces 1 vol. carbon dioxide.

He was not satisfied, and after more failures, together with comments from the members which were anything but helpful, he succeeded in showing a diminution of one-twentieth part of the air (*Birch*, iii, 78). He was instructed to continue with these investigations, and to get some of the members to help him from time to time.

Various Random Experiments—Hooke's Theory re-stated.

In November, 1673, Viscount Stafford produced an account of having kept mercury heated in a vessel for six or seven years (a period which seems to have increased to fifteen years by the end of the month). The vessel was merely covered with a paper and there had been no change in weight. Needham agreed that he had carried out a similar experiment. Then followed mention of an increase in weight of brimstone by fire, and both of these reports were ordered to be entered in the Register Book of the Society (*Birch*, iii, 102, 111). Unfortunately there is no trace of any such entry; it would have been interesting to have discovered how Needham's second result was obtained.

Boyle was reported by Dr. Croune to have published some time afterwards many experiments to prove that substances increased in weight by heating (*P.T.*, viii, 6104).

It was not until January 1679—after Mayow's *Tractatus Quinque Medico-physici* had been published, and after he had become a member of the Society—that the subject was again discussed. Hooke now endeavoured to show the effect of air on respiration and life. He asked for a committee to be set up to investigate this subject because he had not the necessary time, and the experiments naturally occupied a longer period than was afforded by the duration of a single meeting (*Birch*, iii, 450, 452).

An attempt was next made to determine whether air was produced or consumed when gunpowder was burned, but the result was not entered, the minute being incomplete (draft minutes).

Still forcing the Society to take notice of his problem, Hooke enclosed some burning matter in a box and kept the air in the box agitated with bellows. In spite of this agitation, however, the burning ceased, recommencing only when more air was admitted. Hooke satisfactorily performed this experiment three times, but the members decided to ask for more experiments of a like nature in order to verify his theory (*Birch*, iii, 457).

An interesting observation made at this meeting was that the air round a burning candle had a different refraction from that of the surrounding atmosphere. Hooke attributed this to the solution of the material of the flame by the air and the consequent formation of a different kind of fluid.

A week later Hooke again demonstrated the experiment of the fire in an enclosed box, further showing on this occasion that a burning candle was extinguished in the residual air. His theory, expressed once more with perfect clarity, was again stated, namely, that the air was a solvent for all sulphureous

substances and dissolved them by burning, and that in the absence of air no such solution could possibly take place, however great the heat. The Society thought that his theory might at least be further tested (*Birch*, iii, 460).

Further Efforts to verify Hooke's Hypothesis.

From this time onwards Hooke fought hard to convince the members of the correctness of his theory. His next experiment, however, was something of a tragedy ; for when he placed a lighted candle in a vessel in which a fire had burned itself out some days previously the candle continued to burn for some time. Various theories were put forward to account for this, including what was probably the correct explanation, namely, that the air had leaked in (*Birch*, iii, 461).

Hooke then showed that a piece of charcoal could be heated to such a temperature that the glass containing it was red-hot and yet no burning took place. It was then generally agreed that it was the air which consumed, dissolved or corroded the burning body (*Birch*, iii, 463).

A further variation of the last-mentioned experiment was then carried out. The charcoal was surrounded by sand screwed up in an air-tight box by means of an ' iron Screw-pin '. Its weight before being placed in the box was 128 grains. It was heated to bright redness for two hours and, when taken out, weighed only $1\frac{1}{2}$ grains less : this loss Hooke attributed to the moisture in the charcoal (*Birch*, iii, 465).

The meeting of March 13th, 1679, was entirely devoted to the subject of combustion, and most of these experiments were repeated successfully. It seemed as though some interest had been roused at last, especially as a week later objections were raised. The chief of these was that the fire went out because the pores of the air were completely filled with the smoke and vapours so that there was no room for any more. Hooke answered that this could not be so because, if the air was withdrawn, the fire went out even sooner, although there was obviously more ' room ' ; and, moreover, he had already shown that if a greater quantity of air was forced into the vessel the burning would continue even longer (*Birch*, iii, 469).

Many months later these experiments on combustion were again repeated for the benefit of a certain foreign Count who was present at a meeting of the Society.

In addition, it was decided to burn charcoal in a closed space, firstly in still air and secondly in air agitated by the bellows. The lengths of time of burning were found to be exactly the same.

There now followed a long interval again before the subject was reconsidered, and only when Slare tried the effect of phosphorous *in vacuo* was there any approach to it (*Birch*, iv, 195). Slare had recently presented the Society with a ' phosphorus ' of his own making and many experiments were carried out with it.

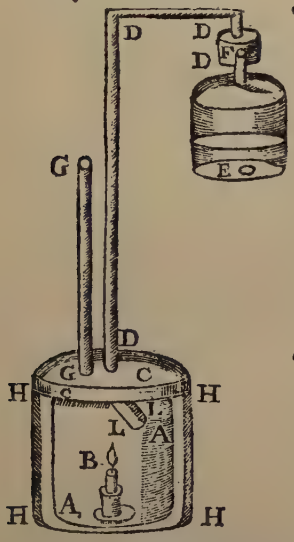
In a discussion on ' aerial magnets ' on March 7th, 1682, mention was made

of the observation that a calx grew heavier in the air, and Slare stated that phosphorus on burning increased by more than four times its own weight (*Birch*, iv, 190).

Papin's Device.

By the year 1685 it was fairly well recognized amongst the Fellows of the Society that air was necessary for burning and that a continual fresh supply of air was needed, and Papin produced an arrangement for maintaining a candle alight under water (fig. 3). He showed that the tubes conveying the air might be of any length and yet the candle would continue to burn, unless the bellows

" Having newly tried a very convenient way to keep a candle burning un-
" der water, I make bold to preſent it to the Royal Society, becauſe I believe it
" may be uſeful for ſeveral experiments.



" AA is a glaſs veſſel.
" B is a candle burning in the ſame.
" CC is a cover exactly fitted to the ſaid veſſel.
" DDDD is a crooked pipe, that makes the com-
" munication between the ſaid veſſel and a pair
" of bellows.
" FF is a pair of bellows with two valves, one in
" E, and the other in F, fitted to let the air
" paſs from the bellows into the veſſel AA,
" and keep it from returning back.
" GG is a ſtrait pipe to let out the air from the
" veſſel AA, when new air comes in from
" the bellows.
" HHHH is a metal plate to faſten the cover CC
" to the veſſel AA.
" LL is a plate to keep the wind, that comes
" thorough the pipe DDD from blowing out
" the candle.

Fig. 3.—The apparatus used by Papin for keeping a candle burning under water. (From *The History of the Royal Society*. Birch, 1747, iv, 360.)

ceased working, in which case the flame of the candle soon went out (*Birch*, iv, 360, 364).

Boyle was very interested in this experiment, but was more concerned, as previously, with collecting the various ' spirits ' of the burning substance.

Examples of Increase in Weight on Calcination.

The following series of results printed in Sprat's *History* [6] clearly demonstrates that the fact of increase on burning was really quite within the bounds of experimental proof, and, in fact, was accepted by the chemists of the day, (*Sprat*, 228).

[6] T. Sprat, *The History of the Royal-Society of London*, London, 1667.

EXPERIMENTS

Of the Weight of Bodies increased in the FIRE: Made at the Tower, and the Account brought in by my Lord BROUNCKER

1. *Copper and Lead.*

	d.	*gr.*[7]
The Coppel weighed	10	$8\frac{7}{32}$
Lead	4	9
Copper	0	6
Into the fire all three...	14	$23\frac{7}{32}$
Out of the fire	15	$4\frac{8}{32}$
Gained	0	$5\frac{1}{32}$

Besides what the Copel lost in weight, supposed to be about three grains.

2. *Copper and Lead.*

	d.	*gr.*
Coppel	10	$2\frac{3}{4}$
Lead	4	9
Copper	0	6
Into the fire all three...	14	$17\frac{3}{4}$
Out of the fire	15	$1\frac{19}{32}$
Gained	0	$7\frac{27}{32}$

3. *Lead Alone.*

	d.	*gr.*
Copel	10	$3\frac{29}{32}$
Lead	4	9
Into the fire both	14	$12\frac{29}{32}$
Out of the fire	14	$3\frac{19}{32}$[8]
Gained	0	$10\frac{22}{32}$

[7] Note that 24 gr. = 1 d.

[8] This is apparently a misprint in *Sprat*, for in the original *Register Book* of the Society this reading appears as: 14 d. $23\frac{19}{32}$ gr.

4. *Lead Alone.*

	d.	*gr.*
Copel	10	$10\frac{7}{8}$
Lead	4	9
Into the fire both	14	$19\frac{7}{8}$
Out of the fire	15	$1\frac{5}{64}$
Gained	0	$5\frac{13}{64}$

5. *Coppel Alone.*

	d.	*gr.*
Into the fire	10	5
Out of the fire	10	$1\frac{3}{8}$
Lost	0	$3\frac{5}{8}$

6. *Copel Alone.*

	d.	*gr.*
Into the fire	10. *wanting*	$7\frac{3}{4}$
Out of the fire	10. *wanting*	9
Lost	0.	$1\frac{1}{4}$.

The New View of Fire.

The early meetings of the Royal Society had, therefore, at least given men the opportunity of bringing together their views and experiments on the problem of burning, and the net result was a much nearer approach to the truth than any theory which arose during the next hundred years. The actual hypothesis formulated may be best presented by quoting from Sprat [9]—' that there is no such thing, as an *Elementary Fire* of the *Peripatetics*; nor *Fiery Atoms* of the *Epicureans*: but that *Fire* is only the Act of the Dissolution of heated *Sulphureous Bodies*, by the *Air* as a *Menstruum*, much after the same manner as *Aqua Fortis*, or other sharp *Menstruums* do work on dissoluble Bodies, as *Iron*, *Tin*, *Copper*: that heat, and light are two inseparable Effects of this dissolution, as heat, and ebullition are of those dissolutions of *Tin*, and *Copper*: that *Flame* is a dissolution of *Smoak*, which consists of combustible particles, carry'd upward by the heat of rarify'd *Air*: and that *Ashes* are a Part of the *Body* not dissoluble by the *Air* '.

[9] *Op. cit.*, 215.

This is, in effect, Hooke's own theory, first propounded by him in his earliest work, *An Attempt for the Explication of the Phaenomena, Observable in an Experiment Published by the Honourable Robert Boyle, Esq.; In the XXXV Experiment of his Epistolical Discourse touching the Aire. In Confirmation of a former Conjecture made by R. H.*, London, 1661, p. 45. Though this tract deals mainly with the rising of liquids by what would now be called surface tension, Hooke applied his explanation to the burning of a candle in the following way :—' And as to the Rising of Oyl, melted Tallow, Spirit of Wine, *&c.* in the Weeck of a Candle or Lamp, it is evident, that it differs in nothing from the former, save only in this, that in a Filtre the Liquor descends and runs away by another part, and in the Weeck the Liquor is dispersed and carried away by the Flame (which what it is, and how it consumes bodies, I shall on some other occasion by many luciferous Experiments manifestly prove) something there is ascribable to the heat, for that it may rarefie the more volatil and spirituous parts of those combustible Liquors, ...'

It is now clear that the ' many luciferous experiments ' were carried out, and all the important facts relating to the problem of combustion were experimentally demonstrated. The consumption of a selected portion of the air, the necessity for a continuous supply of this fluid, the formation of heat and light by the ' composition ', the existence of solids with the essential constituent of the air ' fixed ' in them and available for combustion, and the increase of weight on calcination must be admitted to be almost all the evidence required for the modern theory. These phenomena were linked up with those relating to respiration. The one fact that was not understood seems to be the part played by the air in calcination—the entry of Boyle's ' fire particles ' was generally accepted—and this deficiency prevented the complete synthesis that appears to have been so near at hand. It does seem highly probable, however, that this experimental work was responsible for staving off for a considerable time the adoption of the phlogiston theory. For, although Becher died in 1682, and Stahl in 1734, it is impossible to find any mention of this theory before the Royal Society before the work of Hales, whose first paper was presented in January, 1725/6, and who definitely rejected the idea of loss of oily matter or sulphur on burning. Yet Kirwan (*An Essay on Phlogiston*, London, 1787, p. 2) states that the phlogiston theory was universally adopted throughout Europe by 1736. In fact there was no parallel on the Continent to the work of Hooke, Boyle and Mayow, which was continued by Hauksbee and Papin.

THE TOMB OF JOFUKU OR JOSHI, THE EARLIEST ALCHEMIST OF HISTORICAL RECORD[a].

By [b]TENNEY L. DAVIS, Ph.D., and [c]ROKURO NAKASEKO, Ph.D.

[PLATES V & VI.]

THE *Shih Chi* (Historical Memoirs), which was commenced by Ssŭ-Ma T'an and completed by his son, Ssŭ-Ma Ch'ien (145–87 B.C.), who succeeded him as grand astrologer and grand annalist to the Chinese Court, deals with the history of China from the earliest times to 122 B.C. and reports several cases of alchemical thought and experimentation which, so far as is known, are the earliest recorded instances of the pursuit of the objectives of Alchemy, that is, of the artificial preparation of real gold by chemical means and of the production by chemical processes of a medicine (for the Chinese alchemists the medicine was gold) by the eating of which the user should attain longevity or actual immortality.

The *Shih Chi*, Chapter VI, tells that

> 'it is reported that in the midst of the Eastern Sea there are three supernatural islands. Their names are P'êng Lai, Fang Chang and Ying Chou. . . . They are not far removed from human beings, but unfortunately, at the very time when one is on the point of arriving at the islands, one's boat is blown back by the wind and one finds one's self at a distance. In ancient times—to tell the truth—there were people who succeeded in reaching the islands. It is there that the immortals may be found, and the drug which prevents death. There, all beings—even birds and quadrupeds—are white. The palaces are made of gold and silver. People have not succeeded in reaching the islands a second time. They see the islands from a distance, like a cloud, but, when they approach, the islands are submerged in the water, and when they come quite near, the wind suddenly forces their boat into the open sea. In short, no one has been able to land'[1].

The Ch'in Emperor Shih Huang Ti (259–210 B.C.)—the same who established a new dynasty, built the Great Wall, and introduced the hair pencil or brush for writing on silk instead of on bamboo tablets—became interested in what he heard concerning these islands and the drug which prevents death. The

[a] Paper read before the History of Chemistry Division of the American Chemical Society at Rochester, New York, September 6th, 1937.

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[1] Obed S. Johnson, *A Study of Chinese Alchemy*, The Commercial Press, Ltd., Shanghai, China, 1928, p. 66.

magicians, Lu Shêng and Jsü Shih, influenced him to organize an elaborate naval expedition for the purpose of searching for them :

> ' Hsü Shih and his companions tendered the following request : " We make supplication that we be permitted—after we have purified ourselves—to depart with a company of youths and maidens, to seek these islands." . . . . The Emperor was well pleased. He gave to Hsü Shih seeds of the five grains and dispatched him upon his voyage with three thousand young men and women, and labourers for all kind of work. Hsü Shih sailed away, and discovered a locality noted for its peace and fertility. There he tarried, was made king, and did not return.'

The Emperor, however, continued to hope for his return and restlessly sought news of the expedition and of the wonder-working drug :

> ' When the Emperor had reunited the Empire, he set his face towards the seashore. At that time, magicians in numbers too numerous to be estimated gave expression to their views concerning the immortal islands. The Emperor feared that were he himself to make trial of the sea, he might not succeed. . . . The following year, he returned to make his pilgrimages along the seashore. Three years later he betook himself to Chieh Shih and made a series of inquiries among the magicians who navigate the sea. . . . Five years later he journeyed southward and made ascent of the lofty Huai Chi Mountain. It was his custom to promenade up and down the seashore, in the hope that he might in some manner obtain the wonder-working drug of the three sacred islands in the midst of the sea—but he never obtained it. He returned to Sha Ch'iu—and there he died ' [2].

Further evidence of the truth of the historical record, and of the belief that Hsü Shih's expedition went to the islands of Japan, is found in the fact that an ancient and venerated grave which is supposed to be the grave of Hsü Shih himself, known to the Japanese as Jofuku or Joshi, exists in the city of Shingu, situated at the mouth of the Kumano River, at the eastern extremity of Wakayama Prefecture, near the southernmost end of the Japanese main island. Dr. Nakaseko, whose early home was about thirty kilometres due north of Shingu, in the Nara Prefecture on the same Kumano River, remembers a childhood visit to the tomb, which was then standing in a rice-field on the outskirts of the city. The rice-field and its neighbourhood are now incorporated in the city (population about 32,000), of which they constitute the present Kumanoji Ward. The monument has recently been resanctified, the sacred ground has been widened, walls have been built around it, and trees have been planted. Pilgrims pray at the tomb for longevity and happiness. It is one of the sights for visitors to the Yoshino-Kumano National Park. Dr. Nakaseko has visited the locality again during the summer of 1937 and has inquired into the local traditions concerning Jofuku ; he has also discussed the matter with several of the leading students of Japanese history. The results of his investigations are summarized in the present paper.

[2] *Shih Chi*, Chapter VI ; Johnson, *op. cit.*, pp. 67–68.

The tombstone inscription, in Chinese characters, reads: Ch'in Hsü Fu Chih Mu (2093, 4748, 3707, 1787, 8060)[3], Tomb of Hsü Fu of the Ch'in Dynasty. The Japanese rendering of the characters Hsü Fu is Jofuku, and the characters by which the Japanese write the alchemist's other name, Joshi, are, in Chinese, Hsü Shih (4748, 9905).

If the expedition of Hsü Shih or Hsü Fu, Jofuku or Joshi, did in fact go from China to Japan in search of the drug which prevents death, then certain questions important for our understanding of the origins of Alchemy are suggested. One contemporary Chinese scholar has stated that the facts indicate that Alchemy originated in Japan rather than in China. But this logic seems to us to be loose. The one significant inference which may be made with full confidence, if the truth of the historical record is accepted, is that the notion of the wonder-working drug existed in China, in the place from which the expedition went. We cannot be equally certain that the notion pre-existed in the place at which the expedition arrived.

It is another question whether the wonder-working drug was some natural or supposedly natural material endowed with magical efficacy—in which case the story of the expedition has no place in the history of Alchemy—or whether the drug of immortality was some material prepared by a chemical process. Chapter VI of the *Shih Chi* throws no clear light on this point, but the same work of Ssŭ-Ma Ch'ien in another chapter tells of indubitable cases of Alchemy at the Chinese Court—events which occurred within the lifetime of the historian himself about a century after the expedition of Hsü Shih. Since Alchemy was commonly practised at that time, it seems likely that it was practised somewhat earlier and that Hsü Shih was really an alchemist in accordance with the reputation which he has among those who now come to worship at his tomb at Shingu in Wakayama-ken.

Many magicians frequented the Court of the Han Emperor Wu Ti (156–87 B.C.). The *Shih Chi*, Chapter XXVII, tells that one of them, an alchemist, Li Shao Chün,

> 'constantly affirmed that he was seventy years of age, that he was able to rule over spiritual matters, and that he could escape old age. . . . He travelled about in order that reports of his prowess might reach the ears of nobility. . . . He excelled in showing himself shrewd, and in saying things, at the same time astounding and accurate.'

He proclaimed his powers as follows:

> 'I know how cinnabar transforms its nature and passes into yellow gold. I can rein the flying dragon and visit the extremities of the earth. I can bestride the hoary crane and soar above the nine degrees of Heaven.'

[3] The numbers are those by which the characters are designated in Giles's *Chinese-English Dictionary*, 2nd ed., London, 1912, and serve to identify the characters fully, distinguishing them from others of the same romanization.

He offered instruction to the Emperor:

> 'If you will make sacrifice to the furnace, you will be able to transmute cinnabar into gold. When the gold shall have been produced, you may make of it utensils for eating and drinking. Through using them your life will be prolonged, so that you may see the blessed immortals of the island of P'êng Lai, which lies in the midst of the ocean. When you shall have seen them, and shall have made proper sacrifices to high heaven and broad earth—then you will never die.'

The *Shih Chi* further records that

> 'it was after this discourse that the Son of Heaven for the first time performed in person the sacrifice of the furnace. . . . He occupied himself in experimenting with powdered cinnabar, and all sorts of drugs, in order that he might obtain gold' [4].

The Emperor engaged in chemical experimentation for an alchemical motive.

The *Shih Chi* of Ssŭ-Ma Ch'ien mentions the expedition of Hsü Shih in four places—first among the events of the twenty-eighth year of the reign of Ch'in Shih Huang Ti, at which time (219 B.C.) the expedition is supposed to have set out; secondly, in connection with the events of the thirty-seventh year of the same Emperor; thirdly, in connection with the historical monuments described in his twenty-eighth chapter; and fourthly, in his account of the life of Huai-nan-tzŭ. The same event has been made the subject of frequent conjecture and comment by Chinese writers of every succeeding dynasty. At first they were in doubt as to the place to which the expedition went, but in the Sung dynasty all of them were certain that it went to Japan, and in the Ming that it went to the Kumano region in central Japan. The first Ming Emperor wrote a poem in which he says definitely that

> "there is the shrine of Hsü Fu in Kumano where the garden of medicinal herbs for the elixir is ripe for picking'.

The oldest existing history of Japan, *Kojiki* (Record of Ancient Events), compiled in A.D. 712 from the annals and the stories told by official memorizers, makes no mention of the expedition of Hsü Shih or Jofuku, nor does the equally treasured history, *Nihon-Shoki*, compiled by Prince Toneri-Shimo in A.D. 720. *Jinkō-Seitōki* (The True Lineage of Emperors of Divine Descent), written by Kitabatake Chikafusa in A.D. 1339, tells that the Chinese Emperor Ch'in Shih Huang Ti sent to Japan for the medicine of immortality:

> 'In the reign of Kōrei Tenno, Ch'in Shih Huang Ti liked the art of alchemists (Sen Art) and sent to Japan for medicines of long life and no death. Huang Ti was asked to give in recompense all the ancient books of the "Five Emperors and Three Kings", and these he promptly sent

[4] *Shih Chi*, Chapter XXVII; Johnson, *op. cit.*, p. 70 footnote, pp. 76–77.

> to Japan. Thirty-five years afterwards Huang Ti burned all the books in China and buried all the philosophers and moralists. This is told clearly in books which we get from China nowadays. . . . Although the Chinese books now existing in Japan can be traced back in their oldest form only to those which were brought in by Kibi-no-Mabi in A.D. 735 on his return voyage from China, circumstantial evidence makes us unable absolutely to refute the opinions of the later Chinese scholars.'

The later Japanese writers, Hayashi Razan (about A.D. 1641), Matsushita Kenrin, and Arai Hakuseki (A.D. 1657–1725), have all believed firmly in the statements of the Chinese authors that the Kumano region was the place where Jofuku landed and lived.

The fact that the expedition of Jofuku is not mentioned in the earliest Japanese histories must not be taken as proof that it did not occur. Events which indubitably did take place have escaped the historical writers and story-tellers. Recently there have been excavated, principally in the provinces of Nara, Wakayama, Kyoto, Okayama and the neighbouring provinces, bronze bells of a peculiar design entirely unknown to the Japanese of the present time. To date about one hundred of them have been found. They are about three feet high and about eighteen inches in diameter, of elliptical cross-section. They resemble the ancient Chinese bronze bells of the sixth century B.C. which are pictured in H. G. Wells's *Short History of the World*[5], but differ from them in important respects. The Chinese bells have inscriptions in archaic characters. The Japanese bells have no inscribed characters, but are decorated with wavy lines and with pictures such as that of a man with a bow aiming at a deer, or that of a man and a woman pounding rice in a wooden mortar with a wooden pestle, etc. The pictures show the life of a people who lived in straw-thatched houses supported on piles, such as may now be seen in villages of the southern Philippines, Borneo and Indo-China, and inhabited a country where rice was the staple crop and turtles and crocodiles were familiar animals. The bells may have been used for religious and ceremonial purposes, or perhaps for purposes of war. They are not mentioned in the existing written records nor in ancient stories or legends, in folklore or in mythology. Yet the people who made and used them must have been spread in large and prosperous colonies over the central provinces of Japan. It is evident that there were important events in the history of Japan of which no account has been retained in the record.

If Jofuku did indeed come to Kumano-ura in 219 B.C., he found a fertile and agreeable land, notable for its natural beauty and already inhabited by a vigorous maritime people. The Kuroshiwo current, swinging northward from the Spice Islands of the Pacific, gives the region a subtropical to tropical climate, and makes it, of all the Japanese mainland, the place which a seafarer would be most likely to seek out. According to Japanese history, the Emperor

[5] H. G. Wells, *A Short History of the World*, New York, 1912, p. 172.

Jimmu, the first of the present imperial dynasty, started from the southern part of Kyushu Island on his expedition of conquest, and reached Shingu and the vicinity in 660 B.C., or perhaps a year earlier. This was 441 (or 442), years before Jofuku is supposed to have come there. Jimmu landed his forces and penetrated through the mountainous country to the plains of Yamato in Nara Prefecture, where he established the ' everlasting dynasty ' which rules Japan today. Several Shinto shrines in the neighbourhood have been famous from early times, and have been honoured by eighty-eight recorded personal visits of Emperors on pilgrimage. The Shinto shrine at Shingu traces its origin to the time of the Emperor Jimmu, although its present site was fixed in the reign of the Emperor Keiko in A.D. 73. The shrine at Hongu was established between 65 and 33 B.C., and that at Nachi, twenty-six kilometres north-west of Shingu, in A.D. 317 in the reign of the Emperor Nintoku. The region of Shingu was held in high repute at an early date because of its material and its spiritual attractions. The hot springs of Yukawa have contributed to the health and longevity so intimately associated with the name of Jofuku.

The tradition prevails in the neighbourhood of Shingu that Jofuku did indeed settle there with his ' three thousand young men and women ', and that these same restless and adventurous Chinese were among the ancestors of the people who live there at present. Men of this region have been from earliest times among the most valiant sea fighters. They have been among the bravest sailors of the Japanese Navy, and formerly were the most troublesome pirates of the open sea. Of the 130,000 persons of Japanese parentage in the United States, and of the 150,000 in Hawaii, one-fifth to one-third trace their origin to parentage in Wakayama Prefecture. The early immigration into Japan of large numbers of Chinese is repeatedly recorded in the authentic Japanese historical documents. In A.D. 289 the Royal Prince Ochi-no-Omi, of the Han dynasty, was allowed to settle in Japan with multitudes of his people from seventeen counties. The ancient Chinese colony in Korea in the vicinity of the modern city of Pinyang, which was first settled by the famous Viscount of Chi in 1154 B.C. in the early Chou dynasty, was dispersed about A.D. 300–400, and the people immigrated into Japan by thousands and thousands in the time of the Emperors Ojin and Nintoku. In A.D. 471 a colony of Chinese immigrants, consisting of 18,000 persons divided into 92 groups, was put under the control of Ch'in Shu-kō, an official of Chinese parentage. There are other cases—and the facts all converge to give probability to the traditions concerning Jofuku.

About the middle of the seventeenth century the Feudal Lord of Wakayama Prefecture, Tokugawa Yorinobu, ordered a monument to be erected on the site where, according to local tradition and legend, the tomb of Jofuku had stood from time immemorial. The monument suffered from neglect in the early years of Meiji (1868 onward), and the land pertaining to it was encroached upon by the owners of the surrounding rice-fields. About 1916 a group of

enthusiasts in the neighbourhood raised funds to redeem the land which originally belonged to the monument. They built stone walls around the area, 60×75 feet, and in the middle of it walls around a smaller area, 30×30 feet, within which stands the tomb of Jofuku. Recently they have erected another monument, smaller in size, for the seven disciples of Jofuku. These formerly had their own burial places, separated from each other, each marked by a small shrine, and the seven placed with reference to each other in the manner of the seven stars of the Great Dipper. The original seven shrines have been destroyed one by one, and the sites turned over to the use of industrial establishments. The seven shrines are now combined in one stone monument, erected at the right of the tomb of Jofuku and bearing the inscription ' Monument of Seven Tombs '.

For information and valuable suggestions we wish to make grateful acknowledgment to Professor-Emeritus Masumi Chikashige of Kyoto Imperial University, to Professor Mikinosuke Ishida of the Institute of International Cultural Relations, Tokyo, and to Professor-Emeritus Naoki Kano, Director of the Kyoto Branch of the Oriental Cultural Institute.

Outside of the Inner Wall of the Jofuku Ground.

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THE ALCHEMICAL WORKS OF STEPHANOS OF ALEXANDRIA.

Translation and Commentary by F. Sherwood Taylor, Ph.D., M.A., B.Sc.

Part I.

The long and important alchemical treatise of Stephanos of Alexandria [1] has hitherto been inaccessible to the general reader, since it is not included in Berthelot's *Collection des Anciens Alchimistes Grecs*. The whole Greek text is printed only in the rare *Physici et Medici Græci Minores* of Ideler; portions are contained in other yet rarer works (*v. infra*, p. 118). The present study of the alchemical work of Stephanos will include (1) Introduction, (2) the Greek texts from Ideler with variants from MS. Marcianus Græcus 299, (3) an English translation, (4) commentary, (5) bibliography.

Introduction.

Authenticity and Date of Text.

The authorship of the alchemical texts which are attributed to Stephanos of Alexandria has raised several problems. Earlier scholars [2] identified Stephanos of Athens, a medical writer, with Stephanos of Alexandria: this cannot be regarded as a settled question. Medical works attributed to both these authors exist [3, 4]. Bussemaker [4] considers that the exclamatory and mystical style of the alchemical work is so different from the logical style of the medical works as to be regarded as emanating from a different hand. Dietz [5] is of the same opinion.

Stephanos of Alexandria was an historical personage and flourished under the Emperor Herakleios (610–641 A.D.). He is described [6] as a philosopher and public professor. He lectured on Plato and Aristotle and on the subjects of Geometry, Arithmetic, Astronomy and Music. He left a commentary on Aristotle and an astronomical work. In addition to these, the astrological text (Ἀποτελεσματικὴ πραγματεία) and the alchemical works now in question have been ascribed to Stephanos of Alexandria, but have been held to be pseudepigraphical and of later date by Krumbacher [6] and also by Usener [7] and Kind [3]. The evidence for this view, as far as the alchemical works are concerned, is but slender. It is true that the style of the authentic works of Stephanos differs much from that of the alchemical treatise, but a declamatory and rhetorical style may have been thought appropriate to lectures upon a subject of arcane character: in any event such a style does not indicate a late date, for it is found throughout the Greek alchemical corpus. Kind [3]

regards the alchemical work as of the ninth century, but gives no new evidence for his contention [8]. Usener [7] regards the text as pseudepigraphical on the ground that a public professor teaching in the palace of Constantinople would not have dared to teach Alchemy, the practice of which had been forbidden by the edict of Diocletian. The proscription of Alchemy by Diocletian is supported by the rather slender positive evidence of Suidas and other authors writing at least 300 years after the event. It would seem incredible that the authors of the Greek alchemical texts should be ignorant of this edict, yet it is mentioned by none of them. Negative evidence must give way to positive, but a suspicion must remain as to the historicity of the incident. In any event, as Lippmann [9] has indicated, the edict of Diocletian, some three hundred years before the time of Stephanos, would have carried little or no weight with the learned Emperor Herakleios. The freedom of the alchemical treatise from terms of barbarous origin, such as are found in the latest Greek alchemical texts (*e. g.* that of Kosmas) and the neo-Platonic character of the mystical matter, favour a date before *c.* 700 A.D. The attribution to the well-known Stephanos is to some extent supported by the numerous allusions to mathematical, astronomical and musical matters with which he would be familiar. The alchemical works of Stephanos are cited [10] by the Anonymous Philosopher in a manner which implies that the work of the former author considerably antedates that of the latter, and though there is little evidence for the date of the Anonymous Philosopher we should certainly hesitate to place him as late as the ninth century.

In the absence of any positive evidence to the contrary there seems little reason to refuse to attribute the alchemical texts to the Stephanos of Alexandria who was public professor at the time of Herakleios, but none the less we must contemplate the possibility of the texts being as late as the beginning of the ninth century ; they cannot be later, for the mention of the alchemical text by the *Kitab-al-Fihrist* [11] makes the date of the latter work (probably *c.* A.D. 850) the *terminus ad quem.*

The Alchemical Works of Stephanos.

The alchemical works of Stephanos consist of (1) a long treatise which is subdivided into nine πράξεις or lectures, the last of which has been said to be incomplete [12], and (2) a Letter to Theodore which is interpolated between the second and third lectures.

The titles of these as given in Ideler's edition [13] may be translated as follows :—

(1) Stephanos of Alexandria Universal philosopher and teacher of the great and sacred art. On the making of gold, Lecture I, with the help of God.
(2) The same Stephanos, Lecture II, with the help of God. (Letter of the same Stephanos to Theodore.)

(3) The same Stephanos, on the entire[14] world, Lecture III, with the help of God.
(4) The same Stephanos on that which is in actuality, Lecture IV, with the help of God.
(5) The same philosopher Stephanos upon that part of the divine art which is in actuality, Lecture V, with the help of God.
(6) The same philosopher Stephanos, Lecture VI, with the help of God.
(7) The same philosopher Stephanos, Lecture VII, with the help of God.
(8) The same universal philosopher Stephanos, Lecture VIII, on the division[15] of the sacred art.
(9) Teaching of the same philosopher Stephanos addressed to the Emperor Herakleios, Lecture IX, with the help of God.

Manuscript, Editions and Translations.

The Greek text appears in almost all the Greek alchemical MSS. The text of the treatise has been printed by Ideler in his *Physici et Medici Græci Minores* (Berolini, 1841), vol. ii, pp. 199–253. This text was edited by Dietz from the MSS. of Munich, which are copies of Marcianus Græcus 299, the oldest alchemical manuscript, hereafter referred to as M. The text is not an accurate copy of M.; I have accordingly, through the courtesy of the Director of the Library of St. Mark, obtained photographs of M. and have noted the variants. Berthelot does not print the work of Stephanos in his *Collection des Anciens Alchimistes Grecs*. C. G. Gruner published in 1777 only the first lecture of Stephanos, in Greek and Latin[16].

The work of Stephanos, together with those of Demokritos, Synesios, Pelagios and Psellos, was translated into Latin by Pizimenti. Parts of the translation have been several times reprinted (*v. infra*), but only in the Padua edition (1572–1573) does the portion of the work dealing with Stephanos appear.

The title of Pizimenti's work is: Democritvs Abderita De Arte Magna *Sive de rebus naturalibus*. Nec non Synesii, & Pelagii, & Stephani Alexandrini, & Michaelis Pselli in eundem commentaria. *Dominico Pizimentio Vibonensi Interprete*. Patavii apud Simonem Galignanum MDLXXIII. (Actually first published in 1572.)

This translation was made from the MS. Parisinus Græcus 2249, which is a copy of M. Pizimenti reproduces the sense of the text pretty closely, and the statement of Berthelot that the work is a paraphrase[17] rather than a translation is not fully justified. The obscurity of much of the Greek text made a free rendering necessary. The book is of extreme rarity, for only thirteen copies are known[18]. The translation of the works of Demokritos, Synesios and Pelagios, but not of those of Stephanos, has been reprinted several times[19]. Kopp[2] states that a few manuscript Latin translations of the latter are in existence.

Character of the Alchemical Works of Stephanos.

The work of Stephanos has been decried as rhetorical, as a patchwork etc., and the impression is conveyed that he has merely reproduced the work of older authors. Stephanos was certainly not a practical laboratory worker and his treatise embodies no new experimental results, but if we view it as a document in the history of Alchemy we must accord it high importance. In the first place the treatises of Stephanos and Olympiodoros are the only long and complete, or nearly complete, works on Greek Alchemy which have come down to us. Stephanos gives us a full exposition of the theory of Alchemy as it was understood in the seventh century A.D. He may not be an original writer, but comparatively little of his work is taken from extant alchemical texts. He is the first to avow that the art includes mental operations [20].

The work of Stephanos seems to have been familiar to the Arabs, to whom he was known as Istafan, and as Adfar [21]; he is also mentioned in the *Kitab-al-Fihrist*. Berthelot states [22] that his language differs little from that of Geber, but although his style approaches that of the Arabs more nearly than does that of any other Greek author this is too strong a statement. It is not improbable, then, that this treatise may prove to be an important link between the Greek and Arab schools of alchemical thought.

The numerous mentions of Stephanos in later alchemical literature will be taken up in the bibliography which will follow the translation.

Στεφάνου Ἀλεξανδρέως οἰκουμενικοῦ φιλοσόφου καὶ διδασκάλου τῆς μεγάλης καὶ ἱερᾶς τέχνης[1]. Περὶ χρυσοποιΐας Πρᾶξις σὺν θεῷ πρώτη.

Θεὸν τὸν πάντων ἀγαθῶν αἴτιον καὶ βασιλέα τῶν ὅλων, καὶ τὸν ἐξ αὐτοῦ πρὸ τῶν αἰώνων ἐκλάμψαντα μοιογενῆ υἱὸν σὺν τῷ ἁγίῳ πνεύματι ὑμνήσαντες, καὶ τὸ τῆς αὐτοῦ γνώσεως λαμφθὲν ἡμῖν καθικετεύσαντες, τῆς ἐν χερσὶ πραγματίας, τοῦδε τοῦ συγγράμματος ἀπαρξώμεθα τὰ κάλλιστα δρέπεσθαι, καὶ τὰ ἀληθῆ ἀνιχνεύειν ἐπιστωσάμεθα. νυνὶ δὲ ἐκ τῆς ἀληθοῦς φυσικῆς θεωρίας κατασκευαστέον τὸ πρόβλημα· ὦ φύσις ὑπέρ φύσιν νικῶσα τὰς φύσεις, ὦ φύσις ὑπὲρ αὐτὴν γινομένη οἰκονομηθεῖσα, ὑπεραίρουσα καὶ ὑπιρβαίνουσα[2] τὰς φύσεις, ὦ φύσις μία καὶ ἡ αὐτὴ ἐξ αὐτῆς τὸ πᾶν φέρουσα καὶ ἀποπληροῦσα, ὦ ἕνωσις πληθυνομένη καὶ διάκρισις ἡνωμένη, ὦ ἡ αὐτὴ καὶ οὐκ ἄλλη φύσις, ἐξ αὐτῆς τὸ πᾶν ἀποσώζουσα, ὦ ὕλη ἄϋλος τὴν ὕλην διακρατοῦσα, ὦ φύσις φύσιν νικῶσα καὶ τέρπουσα, ὦ φύσις οὐρανίη πνευματικὴν ἀποστίλβουσα ὕπαρξιν, ὦ ἀσώματον σῶμα, τὰ σώματα ἀσωματοποιοῦν, ὦ σελήνης διαδρομὴ πᾶσαν τὴν διακόσμησιν περιλάμπουσα, ὦ γενικώτατον εἶδος καὶ εἰδικώτατον γένος, ὦ φύσις ἀληθῶς ὑπὲρ φύσιν νικῶσα τὰς φύσεις, ποῖα φύσις εἰπέ, ἡ ἐξ αὐτῆς ἑαυτὴν οἰκείως αὖθις ἀσπαζομένη, ἤτοι ἡ τὸ ἄπυρρον φέρουσα θεῖον καὶ πυρίμαχον ἔχουσα τὸν τόνον, ἡ πολυώνυμος ἰδέα καὶ πολύειδος[3] ἐπωνυμία, ἡ ἔμπειρος φύσις τε καὶ ἐξάπλωσις, ἡ πολλύχρωμος ἐξανθίζουσα ἶρις, ἡ τὸ πᾶν ἐξ ἑαυτῆς ἀνακαλύπτουσα, ὦ φύσις ἡ αὐτὴ καὶ οὐκ ἐξ ἄλλης τὴν φύσιν διαφαίνουσα, ὦ ὅμοιον ἐξ ὁμοίου ἀναφαῖνον[4], ὠκεανίζουσα θάλασσα ποικιλοχρόους[5] ἀναθυμουμένη μαργαρίτας, ὦ συλληψις τετρασωμίας ἐν ἐπιπέδῳ ὡραϊζομένη, ὦ τριττῆς τριάδος ἐπίγραμμα καὶ ὁλικῆς σφαγίδος[6] ἐξάρτισμα, ὦ μαγνησίας σῶμα δι' ἧς τὸ πᾶν ἐπιφέρεται μυστήριον. ὦ χρυσόρροφον[7] οὐρανίης νάμα, καὶ ἀργυρόλοφον ἐκ θαλάσσης ἀναπεμπόμενον πιεῦμα, ὦ ἀργυροθώρακον ἔχουσα χιτῶνα, καὶ χρυσοζώμιον κομίζουσα βόστρυχον, ὦ σοφωτάτων ἐννοιῶν καλὴ γυμνασία, ὦ θειοτάτων ἀνδρῶν σοφὴ παιτουργία, ὦ ἀμυήτων ἀνθρώπων ἀνεξυχνίαστον[8] πέλαγος, ὦ κενοδόξων ἀιδρῶν προκαταλαμβανομένη ἀπειρία, ὦ ὑπερηφάνων μερόπων ἀναθυμουμένη ἔξαψις, ὦ εὐσεβῶν ἀνθρώπων ἀπερικάλυπτος ἀφή, ὦ ἐναρέτων ἀνδρῶν θεωρουμένη ὄψις, ὦ πρακτικῶν φιλοσόφων ἡδύπνοον ἄνθος, ὦ τελεία μονοειδὴς ἀποσκευή, ὦ σοφίας ἔργον, νοοσύνθετον φέρουσα κάλλος, ὦ πᾶν ἐκ μιᾶς οὐσίας τὴν τοσαύτην αἰγὴν

[1] After ἱερᾶς M. has ταύτης; no stop after τέχνης.
[2] M.—ὑπερβαίνουσα.
[3] M.—πολλυώνυμος . . . . πολλύειδος . . . .
[4] M.—. . . . ἐξ ὁμοίου ὁμοιογενὲς ἀναφαῖνον.
[5] M.—ποικιλλοχρώους.
[6] M.—σφραγίδος.
[7] M.—χρυσόροφον.
[8] M.—ἀμοιήτων . . . . ἀνεξιχνίαστον.

TRANSLATION.

STEPHANOS OF ALEXANDRIA THE UNIVERSAL PHILOSOPHER AND TEACHER OF THIS GREAT AND SACRED ART OF THE MAKING OF GOLD. LECTURE I WITH THE HELP OF GOD.

Having praised God the cause of all good things and the King of all, and his only begotten Son resplendent before the ages together with the Holy Spirit, and having earnestly intreated for ourselves the illumination of the knowledge of Him, we will begin to gather the fairest fruits of the work in hand, of this very treatise, and we trust to track down the truth. Now from a true theory of nature our problem must be set out. O nature [23] superior to nature conquering the natures, O nature become superior to itself, well regulated, transcending and surpassing the natures, O nature one and the same yielding and fulfilling the All, O union completed and separation united, O identical and nowise alien nature, supplying the All [24] from itself, O matter immaterial holding matter fast, O nature conquering and rejoicing in nature, O heavenly nature making the spiritual existence to shine forth, O bodiless body [25], making bodies bodiless, O course of the moon illuminating the whole order of the universe, O most generic species and most specific genus [26], O nature truly superior to nature conquering the natures, tell what sort of nature thou art—that which with affection receives itself from itself again, verily that which yields sulphur without fire [27] and has the fire-resisting power, the archetype of many names and name of many forms, the experienced nature and the unfolding, the many-coloured painted rainbow, that which discloses from itself the All, O nature itself and displaying its nature from no other nature, O like bringing to light from its like a thing of like nature, O sea becoming as the ocean [28] drawing up as vapour its many-coloured pearls, O conjunction of the tetrasomia adorned upon the surface, O inscription of the threefold triad and completion [29] of the universal seal, body of magnesia by which the whole mystery is brought about, O golden-roofed [30] stream of heaven, and silver-crested spirit sent forth from the sea, O thou that hast the silver-breasted garment and providest the liquid golden curls [31], O fair exercise of the wisest intellects, O wise all-creative power of men most holy, O sea inscrutable by uninitiated men, O ignorance seized on beforehand by vainglorious men, O smoky kindling of disdainful mankind, O uncovered light of pious men, O countenance contemplated by virtuous men, O sweetly breathing flower of practical philosophers, O perfect preparation of a single species, O work of wisdom, having a beauty composed of intellect, O thou that flashest such

ἐξαστράπτουσα, ὦ σελήνη ἐκ τοῦ ἡλιακοῦ φωτὸς φῶς ἀπολαμβάνουσα, ὦ μία φύσις ἡ αὐτή, καὶ οὐκ ἄλλη φύσις, τέρπουσα καὶ τερπομένη, κρατοῦσα καὶ κρατουμένη, σωζομένη τε καὶ διασώζουσα, τί ὑμῖν καὶ τῇ πολλῇ ὕλῃ, ἑνὸς ὄντος τοῦ φυσικοῦ καὶ μιᾶς φύσεως νικώσης τὸ πᾶν, ποίας ταύτης εἰπέ· ποίας; ὑμῖν τοῖς εὖ φρονοῦσιν ἀνατίθημι τὸ μέγα τοῦτο δῶρον, τοῖς τὴν ἀρετὴν ἠμφιεσμένοις, τοῖς θεωρητικὴν πρᾶξιν κεκοσμημένοις, καὶ πρακτικὴν θεωρίαν ἐνιδρυμένοις· ποίας ταύτης, φράσσον, τοιοῦτον ἡμῖν προμηνύων ἔσεσθαι τὸ δῶρον. ποίας, λέγω καὶ οὐκ ἀποκρύψω. ὁμολογῶ τῆς ἄνωθεν φωτοδοσίας τὴν χάριν, ἣ παρὰ τοῦ πατρὸς τῶν φώτων ἡμῖν δεδώρηται. ἀκούσατε ὡς ἰσάγγελοι νόες. ἀπόθεσθε τὴν ὑλώδη θεωρίαν, ὅπως τοῖς νοεροῖς ὑμῶν ὀφθαλμοῖς ἰδεῖν ἀξιωθῆτε τὸ ἀποκεκρυμένον[9] μυστήριον· ἑνὸς γὰρ τοῦ φυσικοῦ χρεία καὶ μιᾶς φύσεως νικώσης τὸ πᾶν. ποίας ταύτης, ἤδη ὑμῖν σαφῶς λελέχθαι, ὅτι ἡ φύσις τὴν φύσιν τέρπει καὶ ἡ φύσις τὴν φύσιν κρατεῖ, καὶ ἡ φύσις τὴν φύσιν νικᾷ. τέρπεται μὲν ὑπὸ τῆς ἰδίας οὔσης φύσεως, κρατεῖται δὲ τήν ἐξ αὐτῆς ἔχουσα συγγένειαν, νικᾷ δὲ ὑπὲρ φύσιν τὴν φύσιν ὅταν τὴν ἕνσωμον τῆς οἰκονομίας ἀποπληρώσῃ μυσταγωγίαν. ὅταν ἄφθαρτον ἀποθανατώσῃ τὸ σῶμα, ὅταν τὴν πνευματωθεῖσαν μεταποιήσῃ συμπλήρωσιν, τότε ὑπὲρ φύσιν ἔσται θαυμαζόμενον ὡς πνεῦμα, τότε κρατεῖ τὸ κινούμενον σῶμα, τότε τέρπει ὡς ἴδιον οἰκητήριον, τότε νικᾷ ἀσωμάτως κατεμβατεῦον ὅλον ἐξ ὅλου τοῦτο γινόμενον ὑπὲρ φύσιν θαυμαζόμενον. τί εἴπω πρὸς σὲ περιεκτικὴ μαγνησία· τίς μὴ θαυμάσει τὸν ἐκ σοῦ ἀποτελούμενον χρυσοκόραλλον; ἐκ σοῦ γὰρ τὸ πᾶν τελεσιουργεῖται μυστήριον, σὺ τεθάρρησαι μόνη τῆς τοιαύτης τὴν γνῶσιν, ἐν σοὶ ἐφήπλωται ἡ ἀνατολικὴ αὕτη περιλάμπουσα νεφέλη, ὁμοδίαιτον φέρεις ἐν σοὶ τὴν πολύμορφον τῆς Ἀφροδίτης εἰκόνα, οἰνοχόον δὲ πάλιν διακονοῦντα τὸν πυρίβολον ἀνθρακοβάτην (τοσαύτην οὖν ἐπιφέρουσα τὴν τηλαυγίαν νυμφικῶς ἑαυτὴν περικαλύπτεις, τὸ ἔναγνον τῆς φύσεως ἀναλαμβάνεις μυστήριον), δείξω λοιπὸν καὶ τοῦ σοῦ χαρακτῆρος τὴν λαμπηδόνα. ἄρξομαι τὰς πολυμόρφους ἐκείνας μηνύειν εἰκόνας. τότε γάρ σέ τις νοερῶς καθυφαίνων ἔνφλογον τὴν πυρώδη ἐξανάπτει. τὴν σὴν γὰρ θεωρῶν πολύχρωμον φαντασίαν, ἀρκεῖν οὐκ εὐτονοῦμαι περιθέων αὐτῆς τὰ κάλλη. ὁ σὸς γὰρ περιλάμπων μαργαρίτης ἀμαυροῖ μου πρὸς θέαν τὰς κόρας. ὁ σὸς ἐξανάπτων φεγγίτης πᾶσαν μου καταπλήττει τὴν ὅρασιν, ἡ σὴ ἀποστίλβουσα αἴγλη ὅλην εὐφραίνει μου καρδίαν, ὦ φύσις ἀληθῶς ὑπὲρ φύσιν νικῶσα τὰς φύσεις. σὺ τὸ πᾶν ἡ μία φύσις. ἡ αὐτὴ δι' ἧς καὶ τὸ πᾶν γίνεται ἔργον. περιττῷ γὰρ ἀριθμῷ ἡ σὴ τεχνολογεῖται πανκοσμία· τότε γὰρ γνωρίζῃ, ἐν οἷς

[9] M.—ἀποκεκρυμμένον.

a beam from a single being upon all, O moon drawing a light from the light of the sun, O single nature itself and no other nature, rejoicing and rejoiced over, mastering and mastered, saved and saviour, what have you in common with the multitude of material things, since one thing is natural and is a single nature conquering the All ? Of what kind art thou, tell me, of what kind ? To you who are of good understanding I dedicate this great gift, to you who are clothed with virtue, who are adorned with respect to theoretical practice and settled in practical theory. Of what kind, show us, thou who hast indicated beforehand that we should have such a gift. Of what nature, I shall tell and will not hide. I confess the grace of the giving of light from above, which is given to us by the lights of the father. Hear ye as intelligences like to the angels. Put away the material theory so that ye may be deemed worthy to see with your intellectual eyes the hidden mystery. For there is need of a single natural ⟨thing⟩ [32] and of one nature conquering the all. Of such a kind, now clearly to be told you, that the nature rejoices in the nature and the nature masters the nature and the nature conquers the nature. For it rejoices on account of the nature being its own, and it masters it because it has kinship with it, and, superior to nature, it conquers the nature when the corporeal operation of the process shall fulfil the initiation into the mysteries. For when the incorruptible body shall be released from death [33], and when it shall transform the fulfilment which has become spiritual, then superior to nature it is as a marvellous spirit ; then it masters the body moved (by it), then it rejoices as over its own habitation, then it conquers that which in disembodied fashion haunts the whole which is engendered of the whole, that is admirable above nature. Which I say to you is the comprehensive magnesia [34]. Who will not wonder at the coral of gold [35] perfected from thee ? From thee the whole mystery is fully brought to perfection, thou alone shalt have no fear of the knowledge of the same, on thee will be spread the radiant eastern cloud ; thou shalt carry in thyself as a guest the multiform images of Aphrodite, the cupbearer again serving the fire-throwing bearer of coals (then carrying such a brightness from afar, in bridal fashion you veil the same, you receive the undefiled mystery of nature). I will show moreover also the lustre of thy nature, I will begin to indicate thy multiform images. For then he, who intelligently interweaves thee that hast fire within thee, rekindles the fiery thing. For looking on thy many-coloured visions I shall be powerless as I circle round its beauties. For thy radiant pearl blinds the sight of my eye. Thy phengites [36] rekindling astounds all my vision, thy shining radiance gladdens all my heart, O nature truly superior to nature, conquering the natures. Thou, the whole, art the one nature. The same by which the whole becomes the work. For by an odd number [37] thy all-cosmos is systematized. For then thou shalt understand in what respects thou shalt look ahead, then thou shalt discover in what things shall be thy ambit, then thou shalt stop the struggles of the place [38], then thou shalt disclose the kingly purple, which also

προσδοκᾶσαι, τότε ἀνακαλύπτῃ, ἐν οἷς περιδρομεῖσαι, τότε ἀποπαύεις τῆς στάσεως τοὺς ἀγῶνας, τότε μηνύεις βασιλικὴν ἀλουργίδα, ἣν καὶ διὰ τῆς σῆς παιδίσκης ἐπικοπίζῃ[10]· τότε οὐκ ἔναγχος κάματος, ἀλλὰ χρυσόρροφος[11] θάλαμος, τότε οὐ πολύτροπος ἐπιτηδειότης, ἀλλὰ πάνσοφος ἀγχίνοια, τότε οὐ στέρησις τῶν ἐναρέτων ἀνδρῶν εὑρίσκεται, ἀλλὰ ἀπόλαυσις τῶν τελείων ἀνδρῶν ἀναδείκνυται. τοιοῦτος γὰρ αὐτῆς ὁ ἐν περιττῷ ἀριθμῷ εὑρισκόμενος ὅρος. οὕτως αὐτὴν ἐπιγνώσονται οἱ τῆς ἀρετῆς ἀνάπλεοι, ἀκούσατε οἱ τῆς σοφίας ἐρασταὶ καὶ εἴσεσθε τά μεταλία[12] τοῦ παντοκράτορος θεοῦ. αὐτὸς γάρ ἐστιν ὁ πάσης σοφίας χορηγός, φῶς οἰκῶν ἀπρόσιτον, φῶς, ὃ φωτίζει πάντα ἀνθρωπον ἐρχόμενον εἰς τὸν κόσμον. οὐδὲν γάρ ἐσμεν, ἄτερ τῆς αὐτοῦ θεαρχίας, οὐδὲν ὅλως ἐστὶ τὸ ζητούμενον τοῦτο δῶρον πρὸς τὴν αὐτοῦ μακαριότητα. προσεγγίσατε ὦ φίλοι ἀρετῆς πρὸς τὴν ἄϋλον ἐκείνην ἔφεσιν. μάθετε ὡς γλυκὺ θεοῦ φῶς, οὐκ ἄξια τὰ νῦν θαυμαζόμενα πρὸς τὴν μακαρίαν ἐκείνην λῆξιν, μόνον οἰκειωθῶμεν αὐτῷ δι' ἀγάπης, καὶ ληψόμεθα παρ' αὐτοῦ τὴν ἐξ ἀβύσσου ἄβυσσον πηγάζουσαν σοφίαν, ἵνα δυνηθῶμεν διὰ τῆς χάριτος τοῦ κυρίου ἡμῶν Ἰησοῦ Χριστοῦ ποταμοὺς ἀναβλῦσαι ὕδατος ζῶντος, ὅπως θαυμάσας τοῦ δημιουργοῦ τὴν τοσαύτην σοφίαν ὑμνήσῃς αὐτοῦ τὴν εἰς ἡμᾶς μεγάλην φιλανθρωπίαν, τί θαυμάζειν δεῖ χρυσοκόραλλον εἶδος. θαυμάζειν δὲ δεῖ πλέον τὸ ἀπερίγραπτον κάλλος· ὅμως καὶ τὸν πόθον ὑμῶν πληρώσω, ἵνα τοσοῦτον ἐρᾷν ἀξιωθῆτε μεθ' ὑμνωδίας θεολογεῖν τὴν ὑπεράγαθον τοῦ θεοῦ ἀγαθότητα.

[10] M.—ἐπικομίζῃ.
[11] M.—χρυσόροφος.
[12] M.—μεγαλία.

thou shalt bring with thee by the help of thy maiden. Then will not be the recent labour but a couch canopied with gold, then not a multiform ability but an all-wise sagacity, then no deprivation of virtuous men is found, but a fruition of perfect men is displayed. For such is the measure of it found in the odd number.

Thus those full of virtue will discover thee ; hear ye who are lovers of wisdom and know the mighty deeds [39] of the all-ruling God. For he it is that furnishes all wisdom, unapproachable light of houses, light which illumines each man as he comes into the world. For we are nothing apart from his Supreme Divinity ; altogether nothing is the gift which is sought, in respect of his blessedness. Approach, O lovers of virtue, to that immaterial desire. Learn how sweet is the light of God. Unworthy are the things which are now wondered at, in respect of that happy lot. Alone we are made friends with him by love, and we receive from him the wisdom springing forth as an abyss from the abyss, that we may be enabled by the grace of our Lord Jesus Christ to gush forth rivers of living water ; so that wondering at such wisdom of the demiurge we may praise his great kindness towards us. Why should we marvel at the species Chrysocorallos ? We should wonder rather at the infinite Beauty. So also I will fulfil your desire, that you may be made worthy to love such a One ⟨and⟩ with hymnody to discourse of the more than good goodness of God.

Τοῦ αὐτοῦ Στεφάνου συν θεῷ Πρᾶξις δευτέρα.

Τὸ τῶν ἀριθμῶν συγκείμενον πλῆθος ἐκ μιᾶς τῆς ἀτόμου καὶ φυσικῆς μονάδος τὴν ὕπαρξιν ἔχει, ἄπειρον αὐτὴ συντείνουσα τὴν τῶν ἀλλήλων σχέσιν, ὡς ἐξ αὐτῆς προσεληλυθότα περιέχει καὶ περικρατεῖ. μονὰς γὰρ εἴρηται διὰ τὸ μένειν αὐτὴν ἄτρεπτον καὶ ἀμετακίνητον. τὴν γὰρ κυκλικὴν καὶ σφαιροειδῆ τῶν ἀριθμῶν θεωρίαν, ὅμοιαν ἑαυτῆς ἀναδείκνυσιν ἀποκατάληξιν τῶν πέντε ἀριθμῶν φημὶ καὶ τῶν ἕξ· ἐκ γὰρ αὐτῶν εἰς ἑαυτὰ πάλιν ἀνακυκλοῦνται. καὶ πᾶσα μὲν τετραγωνικὴ πλευρὰ ἐξ ἰδιομήκους γινομένη συγγένειαν ἔχει πρὸς τὸ ὅμοιον, ἵνα τελείαν ἀποκαταστήσῃ συμπλήρωσιν. παντὸς δὲ χύματος καὶ μορίων[13] ἑξηκουστόν, ἐξ αὐτῆς τὴν γένεσιν ἔχοντα καὶ ἀνακυκλοῦντα πάλιν εἰς ἑαυτὴν συστελλόμενα τὴν φυσικὴν ἀποπληροῦσι μονάδα. πάσης δὲ κυκλικῆς σφαίρας τὸ σημεῖον κέντρον ἐστίν, ὁμοίως δὲ καὶ παντὸς τριγώνου καὶ ἐπιπέδου καὶ στερεοῦ σχήματος διὰ γραμμῶν τιθέντος, τὸ αὐτὸ συννοείσθω. καὶ τῆς μουσικῆς δὲ ἱστορίας οἵ τε νέατοι καὶ παρύπατοι, εἰ δὲ ἐκ τεσσάρων, εἰδὲ ἐπὶ τρίτῳ λόγῳ, τότε πρὸ αὐτοῦ πρόλογον εἶναι καὶ τὸν ὑπ' αὐτοῦ ὑπόλογον, δι' ἧς τὰς τοιαύτας τῶν ἀναλογιῶν συνδέσεις, καὶ διὰ πασῶν[14] αὐτῶν συμφωνίας ἐκ τῆς τοσαύτης αὐτῶν ἀνασώζομεν μουσικῆς ἱστορίας. Ὀρφέα γάρ φησι ληχάνοντες ῥυθμικοῖς[15] ἐνηρμόσθαι φθόγγοις, ὥστε καὶ τῆς ὁμοταγοῦς οὐσιῶν[16] κινήσεως ἡ συμφωνία ὑπηχεῖται[17], καὶ τὴν ᾄδουσαν ἐμμελῶς ἐκτελεῖ μελῳδίαν. ἐξ ἑνὸς γὰρ της τοῦ ὀργάνου ἡ τούτων συνίσταται κατασκευή, ὅθεν καὶ τὴν ἔναρθρον τοῦ σώματος κατασκευὴν οὕτως διακεῖσθαι ὀστέοις τε καὶ ἄρθροις καὶ μορίοις καὶ νεύροις, καὶ διὰ τοῦ πλήκτρου ἀναδιδομένου ἀέρος δίκην ὀργάνου κινοῦντος τὴν φωνὴν ἀποπέμπεσθαι εἰς ἕν τι τῆς οὐσίας συναρμοσθέντα καὶ ἑαυτῆς βία κρατούμενα καὶ συνιστάμενα· τὸν αὐτὸν δὴ τρόπον καὶ τὴν τοῦ ἀέρος σύγκρασιν. δύο γὰρ ἄκρων ποιοτήτων, εἷς μεσίτης καὶ διαλλάκτης εὑρίσκεται, σώζων αὐτῶν τὰ ἑκάτερα, διὰ τὴν πρὸς αὐτὰς γειτνίασιν καὶ πολλὴν συγγένειαν. ἀλλὰ καὶ τῆς σφαιροειδοῦς καὶ ἀπλανοῦς ταύτης τῆς τοῦ πόλου κινήσεως, ἐκ τῆς τοῦ ὑπὲρ γῆν ἡμισφαιρίου παρὰ τοῦ ὁρίζοντος τόν ἐγκόσμιον τοῦτον καὶ διαφανῆ πόλον, καὶ τοῦ ἡλιακοῦ φωτὸς ἐκ τῆς[18] πᾶσι τούτοις ἐπιχορηγοῦντος τὰ φῶτα καταυγάζει. ἐξ αὐτῆς γὰρ οὐ μόνον οἱ ἀστέρες τὴν τοῦ φωτὸς μετέχουσι τάξιν, ἀλλὰ καὶ ἡ τῆς σελήνης ἐπιφάνεια τὴν ἐκ τοῦ φωτὸς ἐπιλαμβάνουσα αὐγήν, φαίνει τε πᾶσαν τὴν νυκτερινὴν λαχοῦσαν δᾳδουχίαν. καὶ ἔξεῖς πάντα ἁπλῶς εἰπεῖν τὰ τοιαῦτα ἐκ τοῦ ἑνὸς αὐτῶν καὶ πρωτίστου τὴν οὐσίαν εἰληχότα, σώζουσι τὰ τῆς φύσεως καὶ ἀποπληροῦσι θεωρίας. καιρὸς ἂν εἴη λοιπόν, τὴν ἐν τῷ προάγοντι

[13] M.—Stop after μορίων.
[14] M.—διαπᾶσων.
[15] M.—Ὀρφαίου . . . . ῥυθμιτικοῖς.
[16] M.—ἐνηρμῶσθαι. For οὐσιῶν M. reads αὐτῶν.
[17] M.—ὑφηχεῖται.
[18] For ἐκ τῆς M. reads ἀκτὶς, and for πᾶσι, πᾶσιν,

SECOND LECTURE OF THE SAME STEPHANOS WITH THE HELP OF GOD.

The multitude of numbers compounded together has its existence from one atom and natural monad ; this, which itself exerts a mutual condition, comprehends and rules over the infinite as emanating from itself. For the *monad* [40] is so called from its *remaining* immutable and unmoved. For it displays a circular and spherical contemplation of numbers like to itself, I speak of a completion of the five numbers and of the six. For from these they come round again to themselves. And every side of a rectangle generated from the same length has kinship to its like that it may restore a perfect fulfilment. For the sixtieth part of every great quantity and of fractions, taking origin from it ⟨the monad⟩ and returning again to it, being contracted together, complete the natural monad. The symbol of every circular sphere is the centre, likewise of every triangle and plane and solid figure set out by lines ; let this same be thought of.

Also of the musical learning, both the lowest strings and that next the first, whether of four strings or upon the third ratio, that which is before it must be the antecedent and that after it the consequent, by which we preserve the binding together of the proportions and of the whole scale of harmony [41] as a result of such musical learning.

For they who pluck the strings [42] say that Orpheus made melody with rhythmical sounds so that the symphony should re-echo the co-ordinated movement of the elements and the sounding melody should be harmoniously perfected. For from the one instrument the whole composition takes its origin, whence also the organization of the articulate body is ordered in the bones and joints and parts and nerves, and by the plectrum of the air, given forth in the fashion of a moving instrument, a voice is sent forth to the One which is joined to its essence and which conquers and organizes it by its own life : the very mode and blending of the air. For of two extreme qualities there is found one mediator and conciliator which preserves the qualities of both on account of its resemblance and close kinship to them. And also the movement of the pole being spherical and stable, the light of the hemisphere which is above the earth, arising from the line dividing the mundane and the diaphanous pole, also radiates forth the fires of the sunlight ⟨derived⟩ from that which supplies it to all things. For from it not only do the stars partake of the order of the light, but also the appearance of the moon, giving out rays derived from the light, displays its nightly allotted torchbearing. And you shall have all such things to speak of singly, as derived from one of them, and as the essence of the very first returned again ; they preserve the things of the nature and fulfil the contemplation. But were there time enough to consider our discourse in the progress of a proem, (I would speak of) that

τοῦ προοιμίον σκέψασθαι διάλεξιν, καὶ τὸ τῆς σεληνιακῆς ἀπορροίας πῖπτον, πῶς δὲ εὑρίσκεται, καὶ πῶς οἰκονομεῖται, καὶ πῶς ἄκαυστον ἔχει φύσιν. ὦ διδασκαλίας σοφία τῆς τοιαύτης κατασκευῆς διασημαίνουσα τὸ ἔργον, ὦ λευχημονοῦσα σελήνη[19] ἀποστίλβουσα λευκότητα, μάθωμεν τίς αὕτη ἡ σεληνιακή, ἵνα τό ἀπορούμενον μὴ διαλάθωμεν. ἔστι δὲ αὕτη ἡ λευκοφόρος χιών, τὸ πολύφωτον ὄμμα τῆς λευκασίας, ἡ νυμφαγωγὸς στολὴ τῆς οἰκονομίας, ὁ ἄφθαρτος χιτών, τῆς εὐμορφίας τὸ νοοσύνθετον κάλλος, τῆς τελειώσεως τὸ λευκότατον σύνθεμα, τῆς ἀποπληρώσεως τὸ πηκτὸν γάλα, τῆς θαλάσσης τὸ ἀφροσέληνον ἐῴας, ἡ μαγνησία τῆς Λυδίας, τὸ ἰταλικὸν στῆμι, τῆς Ἀχαΐας ὁ πυρίτης, ὁ ἀπὸ Ἀλβανίας, τὸ πολυώνυμον τῆς ἀγαθοεργίας, ἡ τὸ πᾶν ἐπικοιμίζουσα, ἡ τὸ ἓν πᾶν[20] φέρουσα, ἡ τὸ θαυμαστὸν ἔργον ἀποπληροῦσα· τί δέ ἐστιν ἡ ταύτης ἀπόρροια; οὐκ ἀποκρύψω, ἀλλ' ἐμφανὲς δείξω τὸ ζητούμενον κάλλος. ἔστιν οὖν αὐτῆς ἡ ἀπόρροια τὸ ἐν αὐτῇ κεκρυμμένον μυστήριον, ὁ πολύτιμος μαργαρίτης, ὁ φλογοφόρος φεγγίτης, ὁ χρυσοράντιστος χιτών, τὸ χρυσοζώμιον βρῶμα, ὁ χρυσόκοσμος σπινθήρ, ὁ νικηφόρος ἀνθαγαθεὺς[21], τὸ βασιλικὸν περιβόλαιον, ἡ ἀληθινὴ πορφύρα, τὸ πολυτίμητον στέμμα, τὸ ἄπυρρον θεῖον, ὁ εἰσκριτὴρ τῶν σωμάτων, τὸ ξανθὸν ὅλον εἶδος, ὁ ἐγκεκρυμμένος θησαυρός, ὁ θάλαμον ἔχων τὴν σελήνην, ὁ ἐν αὐτῇ τῇ σελήνῃ γνωστικῶς θεωρούμενος, ☽ ☿ ♀ ♀ ☿ η, αγς ρ ♀ ω[22]. ὁ λευκὸς μὲν θεωρούμενος, ξανθὸς δὲ γνωριζόμενος, ὁ τῇ λαχούσῃ σελήνῃ νυμφίος, ἡ ἐξ αὐτῆς χρυσῆ σταγών, ἡ ἀπ' αὐτῆς ἐνδοξος ἀπόρροια, ἡ ἀναλλοίωτος συμπλοκή, ἡ ἀνεξάλειπτος περιδρομή, ἡ θεοδώρητος ἐργασία, ἡ θαυμαστὴ χρυσοποιΐα, καὶ ἵνα μὴ ταύτην παραδράμω, ἐπὶ τὸ προκείμενον αὖθις ἐπάνειμι τοῦ λόγου. μετὰ τὴν τοῦ χαλκοῦ ἐξίωσιν καὶ ἐξίσχνωσιν καὶ μέλανσιν ἐφ' ὕστερον λεύκωσιν, τότε ἔσται βεβαία ξάνθωσις. ὦ σοφίας ἔργον ὑπὲρ φύσιν θαυμαζόμενον, ὦ ἄφθονος χάρις δαψιλῶς ἐκπηγάζουσα, οὐ φθονεῖ ὁ σοφώτατος, ἀλλ' ὑποδείκνυσι σαφῶς τὴν ἐξήγησιν. [μετὰ τὴν τοῦ χαλκοῦ ἐξίωσιν καὶ ἐξίσχνωσιν καὶ μέλανσιν, εἰς ὕστερον λεύκωσιν, τότε ἔσται βεβαία ξάνθωσις.] τί λέγεις φιλόσοφε μετὰ τὴν τοῦ χαλκοῦ ἐξίωσιν; ποίαν ταύτην; εἰπέ, φράσσον ἡμῖν τῆς ἐργασίας τὰ ἀπόκρυφα. μετὰ τὴν τοῦ χαλκοῦ ἐξίωσιν, καὶ πῶς ἐστιν ἐξιῶσαι χαλκὸν τὸν ἰὸν ὅλον φέροντα; πῶς; ἐγὼ ὑμῖν λέξω τοῦ λόγου τὴν ἀκρίβειαν, τὴν διὰ νεφέλης βαδίζουσαν Ἀφροδίτην. μετὰ γὰρ τὴν τοῦ χαλκοῦ ἐξίωσιν, τουτέστιν καλῶς οἰκονομηθεῖσαν λείωσιν καλῶς προβιβασθεῖσαν περίσκεψιν, μετὰ γὰρ τὴν τοῦ χαλκοῦ[23] αὐτοῦ καὶ ἐξίσχνωσιν τουτέστιν λεπτοτέραν τῆς λειώσεως διάθεσιν, καὶ ἔτι τὴν ἐπακολουθοῦσαν τούτοις ἐπιφερομένην μελανίαν εἰς ὕστερον εἴρηται λεύκωσιν, τότε ἔσται βεβαία ξάνθωσις. ὅταν γὰρ τὴν τῆς ῥυτίδος ἀποπτύσῃ μελανίαν, εἰς λευκότητα λίαν μεταφέρεται. καὶ ὅταν εἰς λευκότητα λίαν μεταφέρηται, τότε τοῦ στιλπνοῦ φωτὸς ἡ σελήνη ἀπαυγάζει τὰς ἀκτῖνας, τότε πότε, εἰς ὕστερον λεύκωσιν, ὅτε λευκὸν ἴδῃς τὸ σύνθεμα· ὅτε γὰρ πλησίον σελήνης φανῇ, τότε τὸ πανσέληνον αὐτῆς μηνύει τὸ φῶς. τότε βεβαία ἡ ξάνθωσις. ποία αὕτη; εἰπέ. ἡ θεωρουμένη λευκή. καὶ πῶς τὸ λευκὸν ξανθὸν ἀποτελεῖς;

[19] After σελήνη M inserts πάνυ.

[20] M.—ἡ τὸ ἓν τὸ πᾶν . . . .

[21] For ἀνθαγαθεὺς M. reads ἀνδραγαθεὺς.

[22] See note [50].

[23] M. has τοῦ χαλκοῦ αὐτοῦ τοῦ χαλκοῦ.

which falls from the moon's waning [43], how it is found, how it is treated, and how it has an unburnt nature. O wisdom of teaching of such a preparation, displaying the work, O moon clad in white and vehemently shining abroad whiteness, let us learn what is the lunar radiance that we may not miss what is doubtful. For the same is the whitening snow, the brilliant eye of whiteness, the bridal procession-robe of the management of the process, the stainless chiton, the mind-constructed beauty of fair form, the whitest composition of the perfection, the coagulated milk of fulfilment, the Moon-froth [44] of the sea of dawn [45]; the magnesia of Lydia, the Italian stibnite, the pyrites [46] of Achæa, that of Albania, the many-named matter of the good work, that which lulls the All to sleep, that which bears the One which is the All, that which fulfils the wondrous work. What is this emanation of the same (moon)? I will not conceal it, but will display visibly the sought-for beauty. For the emanation of it is the mystery hidden in it, the most worthy pearl, the flame-bearing moonstone, the most gold-besprinkled chiton, the food of the liquor of gold [47], the chrysocosmic [48] spark, the victorious warrior, the royal covering, the veritable purple, the most worthy garland, the sulphur without fire, the ruler [49] of the bodies, the entire yellow species, the hidden treasure, that which has the moon as couch, that which in the moon is gnostically seen as ⲭⲟⲩ ⲱ ⲩⲏⲇⲥⲫⲩⲱ· [50]. For it is white as seen, but yellow as apprehended, the bridegroom to the allotted moon, the golden drop (falling) from it, the glorious emanation from it, the unchangeable embrace, the indelible orbit, the god-given work, the marvellous making of gold, and that I may not pass over the same, I will return again to the present matter of the discourse. 'After the cleaning of the copper and its attenuation and blackening before the latter whitening, then is the stable yellowing' [51]. O work of wisdom above nature wondered at, O unstinted grace amply gushing forth, the Wisest [52] is not envious, but clearly displays his explanation. After the cleaning of the copper and its attenuation and blackening, to the later whitening, then is the solid yellowing. Why say you, philosopher, 'after the cleaning of the copper'? What same (do you mean)? Speak, tell to us the secrets of the work. 'After the cleaning of the copper', and how is one to clean the copper yet bearing all its *ios*? [53] How? I will tell you the accurate meaning of the phrase—Aphrodite walking through a cloud. 'After the cleaning of the copper', that is a trituration well managed, a consideration well taught beforehand; 'After the attenuation of the copper', that is a finer condition of trituration, he also speaks of the blackness placed upon it and following upon these for the purpose of the later whitening; then is the solid yellowing. For when it shall spurn the blackness of the wrinkled crust [54], it is transformed to whiteness; then the moon of shining light shall send forth the rays; then ⟨one comes⟩ to the later whitening, when you shall see the white compound. For when the full of the moon appears, then the full moon discloses its light. Then solid is the yellowing. What is this? Say. The whiteness perceived. And how do you render the white yellow? Ye wisest of men, over-pass the

ὦ σοφώτατοι, ὑπερβαίνει λογισμόν, τοῦτο κρύφιόν ἐστιν τὸ ἐρώτημα, μυστικὴ λέξις καὶ ἡ ἐπίσκεψις. ἐγὼ φράσω τὸ μυστήριον τὸ ἀπόκρυφον καθὼς ἀνωτέρω ὑμῖν προλέλεκται· μετὰ τὴν τοῦ χαλκοῦ ἐξίωσιν καὶ ἐξίσχνωσιν καὶ μέλανσιν εἰς ὕστερον λεύκωσιν, τότε ἔσται βεβαία ξάνθωσις. ὅτε ἴδῃς τὴν γινομένην λεύκωσιν ἔνδον αὐτῆς, ἐπιγίνωσκε τὴν περικεκαλυμμένην ξάνθωσιν, τότε ξανθὴν νόει τὴν λεύκωσιν οὖσαν, τότε καὶ λευκὴ οὖσα, ξανθοῖ διὰ τὴν ἐν αὐτῇ ἀποκεκρυμμένην ξάνθωσιν, διὰ τὸ ἐμβατεύειν αὐτῆς τὰ τῆς καρδίας βάθη διὰ τὸ ἔνσωμον ἔχειν τὴν τῆς ☽[24] λεύκωσιν, καὶ ἀρρήτως ἐν αὐτῇ τὴν ξάνθωσιν διήκουσαν. τότε βεβαία ἔσται ξάνθωσις· ποῖα; ἡ γινομένη λευκή· αὕτη ἐστὶν ἡ ξανθή. αὕτη μὲν τῷ χρώματι λευκὴ φαίνεται, ἡ δὲ φύσις ξανθὴ ὑπάρχει, οὐδὲν ὑπολέλειπται, οὐδὲν ὑστερεῖ, πλὴν τῆς νεφέλης καὶ τοῦ ὕδατος ἡ ἄρσις. βλέπεις τὸν ἀρχαιότατον. οὐχ ὁρᾷς τί ἀπεφήνατο ὁ σοφός; οὕτως αἰνίττεται ὡς τελείως. οὕτως ἀπεφήνατο ὡς καθηγητὴς τὸ πᾶν ἀποδείκνυσι λέγων, οὐδὲν ὑπολέλειπται, οὐδὲν ὑστερεῖ, πλὴν τῆς νεφέλης καὶ τοῦ ὕδατος ἡ ἄρσις· δείξας ἐν τούτῳ τὴν τοῦ ὅλου κατασκευήν, ἀποδοὺς δι' ὀλίγου τὸ πᾶν, ἵνα μὴ πολλῇ ὕλῃ καταχώσητε τὰ κινούμενα, ἵνα μὴ Κιλικίας τὸν κρόκον, καὶ ἀναγαλλίδος βοτάνη καὶ τὸ Πόντιον αὐτοῖς ῥᾷ, καὶ τῶν ἄλλων ὀπῶν, χολῆς τετραπόδων καὶ κνωδάλων τινῶν, λίθον τε καὶ μετάλλων φθαρτικῶν νοήσωσι, τὰ τῆς τελεσιουργικῆς καὶ ἑνικῆς καὶ μιᾶς φυσεως τὰ ἀνόμοια, ἵνα μὴ πλανηθέντες ἄνθρωποι ἀποστῶσι τῆς ἀληθείας, ἵνα μὴ ἐπὶ τῆς φυσικῆς ὑπάρξεως ἀνύπαρκτον διάθεσιν μετέλθωσιν. τί λοιπόν; ὁ ἐξοχώτατος καὶ πάσης ἀρετῆς σύμβουλος, περιάγων αὐτοὺς καὶ ἕλκων πρὸς τὸν τῆς ἀληθείας σκοπόν, ἵνα μὴ ὡς ἔφην εἰς ὑλικὰς καμίνους καὶ διοργανισμοὺς ὑελῶν, ἀμβύκων, λωπάδων τινῶν καὶ κηροτακίδων καὶ αἰθάλων. καὶ οἱ εἰς τὰ τοιαῦτα ἐπασχολούμενοι εἰς κενὸν αὐτοῖς ὁ τοῦ καμάτου πόνος ἐξαγορευθῇ· ἀλλ' ὅρα πῶς ἐν τῇ φράσει τὸ πᾶν ἀπεπλήρωσεν. οὐδὲν ἀπολέλειπται, οὐδὲν ὑστερεῖ πλὴν τῆς νεφέλης καὶ τοῦ ὕδατος ἡ ἄρσις. ποία νεφέλη; εἰπέ. τίς ἡ νεφέλη καὶ τι τὸ ἐξ αὐτῆς ἐκτελούμενον ἔργον; δεῖξον ἡμῖν φανερώτατα, ὅπως ἐπιγνωσώμεθα τοῦ λόγου τὴν δύναμιν. καὶ πρὸς ταῦτα ὁ φιλόσοφος· νεφέλη ἐστίν, τοῦ ὅλου συνθέματος ἔργον, ἡ διὰ τοῦ θείου ὕδατος καλῶς ἀποστίλβουσα, ἡ ἐμφυῶς τὴν λείωσιν ποιησαμένη, ἡ οἰκονομικῶς φαινομένη, καὶ νοητῶς καταλαμβανομένη. νεφέλη ἐστὶν ἡ τῆς ἐργασίας ἐξάπλωσις, ἡ ἐπίπεδος ἐπιφάνεια, ἡ ἀργυρώνητος στήμων, ἡ ἀεροϋφαντος περιπλόη, ἡ Κελτικὴ νάρδος, τὸ Ἀτλαντικὸν πέλαγος, ἡ Βρεττανικὴ μέταλλος, ὁ στεφανόκοσμος ὠκεανὸς, ἡ ἀμέτρητος ἄβυσσος, ἡ σφαιρόμορφος κτίσις, τὸ οὐράνιον σῶμα, ἡ τὸ πᾶν περιέχουσα καὶ περιλαμβάνουσα, αὐτὸ τὸ εἶδος τὸ ἀτίμητον, ἡ ποθουμένη θεωρία, τὸ ζητούμενον θέαμα, τὸ ἓν ὅλον καὶ ὅμον ἕν, ἡ ἱερὰ λεύκωσις τοῦ παντὸς τιμίου ἔργου, ἡ ὅλη κατασκευή, τὸ ἐνεπίστημον ἔργον[25], τὸ συμπέρασμα τῆς συμπληρώσεως, τὸ λειωθὲν καὶ καλῶς οἰκονομηθέν, τὸ

[24] M. has ☾ in place of ☽.

reasoning, this answer is a secret, a mystic speech and consideration. I will tell you the hidden mystery, whence it is proclaimed above you. ' After the cleaning of the copper and its later attenuation and the blackening for the later whitening, then is the solid yellowing.' When you see the whitening taking place within it, recognize the concealed yellowing, then know the whitening as being yellow ; then also being white, it becomes yellow by the hidden yellowness, by possessing the depths of its heart, by having the corporeal possession of the whiteness of the silver and, unutterably, the pervading whiteness in it. ' Then is the solid yellowing.' What is this ? That which has become white, it is the yellow. For the same white appears in the colour, but the yellow nature overrules it. ' Nothing is left remaining, nothing is left behind except the vapour and the raising of the water ' [55]. Consider the most ancient one [56]. Do you not see what the wise man has declared ? Thus he speaks in riddles as completely as possible. Thus he declares, as a teacher demonstrates everything, saying ' nothing is left remaining, nothing is lacking, except the vapour and the raising of the water '. Having shown in this the preparation of the whole, rendering all in few words, that ye may not overwhelm the moving things with much matter, that ye may not think about saffron of Cilicia [57] and the plant of anagallis [58], and the Pontic rhubarb [59] for themselves, and of other juices, gall [60] of quadrupeds and certain beasts, of stones and of destructive minerals, things that are dissimilar to the perfection-making, single and one nature, that men wandering shall not be led away from the truth, in order that in a natural existence they shall not seek for a non-existent tendency. What else ? The most eminent man and counsellor of all virtue turns them around and draws them to the view of truth, that you may not, as I said (take note of) material furnaces and apparatus of glasses, alembics, various flasks, kerotakides and sublimates. And those who are occupied with such things in vain, the burden of weariness is declared by them [61]. But see how the All is fulfilled in the phrase. ' Nothing is left remaining, nothing is lacking save the vapour and the raising of the water.' What kind of vapour ? Say. What is the vapour and what is the work brought to perfection by it ? Show us most clearly the way in which we may recognize the power of the word. And on this matter the philosopher says : ' the vapour is the work of the composition of the whole ' [62], that which shines brightly through the divine water [63], that which makes the trituration naturally, that which appears in the course of the method, and is apprehended intellectually [64]. The vapour is the unfolding of the work, the level manifestation, the thread bought with silver, the air-displaying voyage, the Celtic nard [65], the Atlantic sea, the Britannic metal [66], the ocean garlanding the world, the unmeasured abyss, the sphere-shaped universe, the heavenly body, that which encompasses and embraces the all, the despised species, the longed-for contemplation, the sought-for spectacle, the one whole and whole one, the holy whitening of the whole worthy work, the whole preparation, the one work of wisdom, the conclusion of the fulfilment, that which is triturated and well managed, the

τελείως πληρωθέν. οὐδὲν γὰρ ὑπολέλειπται, πλὴν τῆς νεφέλης καὶ τοῦ ὕδατος ἡ ἄρσις. τὸν τῆς νεφέλης σαφῶς ἐφοδηγηθέντες [26] τρόπον, ἐπὶ τὴν τοῦ ὕδατος ἄρσιν μετελεύσώ μου τὸν λόγον. τί ἄρα ἐστὶ τοῦτο τὸ ἐπαγόμενον; τίς ἡ τοῦ ὕδατος αὕτη ἄρσις; εἰπὲ ὦ καθηγητά· πλήρωσον σοῦ τῆς χάριτος τὰς δωρεάς· καταύγασον ἡμῶν τὰς ἀμβλυώπους κόρας, σαφήνισον τὴν τοῦ λόγου ἔναρθρον σύστασιν, τίς ἡ τοῦ ὕδατος αὕτη ἄρσις; καὶ περὶ τούτου οὐκ ἀπεσιώπησεν· εἶπεν, τὸ ἀμιγὲς κάλλος ὕλην οὐχ ὑποδέχεται, ἡ ἄϋλος οὐσία, ἁπλὴ μέν ἐστι καὶ σύνθετος, τὸ μυριώνυμον τοῦτο ἀγαθόν. μιᾶς γὰρ ὕπαρχον οὐσίας, εἰς ἑαυτὴν συστέλλεται, περὶ αὐτὴν ἀναπαύεται [27] τὴν μίαν αὐγὴν τὰς ὑγροποιοὺς ὅλως οὐκ ἐντίθεται ἀκμάδας [28]. ἀποβολὴν δὲ ἔληθεν τῶν ῥευμάτων τὴν βίαν· ἀποθεῖται τῶν ὑδάτων τὰς ῥύσεις· πῶς γάρ ἐστιν αὐτῆς ἰδεῖν τὴν κίνησιν, μὴ οὕτως ταῦτα ἀποσεισαμένης; οὐ δύναταί τις αὐτῆς ἐμπλησθῆναι, εἰ μὴ πρῶτον ἐξάρῃ ἀπ' αὐτῆς τὰ περιπολεύοντα ὕδατα. δεῖ οὖν νηχομένην αὐτὴν τοῖς ὕδασι, μὴ ἐὰν αὐτὴν ἔνυγρον, ἵνα μὴ ἀποφρενωθῇ, ἵνα μὴ δύνῃ ἀφ' ἡμῶν, ἵνα τι τῇ ὑγρᾷ οὐσίᾳ ἐνύγρως ἀπομείνῃ. ἀλλ' ἄρωμεν ἀπ' αὐτῆς τὴν τῶν ὑδάτων περιοχήν, ἵνα θεασώμεθα τοῦ κάλλους αὐτῆς τὴν πολλὴν εὐοπτίαν. πῶς οὖν τὴν τοῦ ὕδατος ἄρσιν ποιησόμεθα; πῶς ἀπώσομεν ἐκ τῆς τοῦ ὕδατος μετουσίας; πῶς αὐτὴν διασπάσομεν, ἵνα οὕτως εὐχερῶς τοῦ ὕδατος γένηται ἄρσις; πανοπλίας χρὴ καὶ ἀνδραγαθίας. τίς ἱκανὸς πρὸς τοῦτο; τίς δυνατὸς ἐξάραι τὴν πλημμυρίζουσαν τῶν ὑδάτων διαδρομήν; τίς οὕτως εὑρίσκεται πρὸς ἀντίστασιν; τίς πρὸς διακονίαν εὐτρεπίζεται; εὕρηται ἡ εὐλυσία τοῦ πράγματος, ἵνα φανερῶς ἴδωμεν τῆς νεφέλης τὴν ὡραιότητα. αὕτη ἐστὶν ἡ διὰ τοῦ θείου ἔμπειρος παρύπτησις. ὥσπερ γὰρ ἡ διὰ του ὕδατος ἐπὶ νῷ ἐστιν [29] ἀπόπλυσις, οὕτω [30] καὶ διὰ θείου ἀποκάθαρσις τοῦ παντὸς γίνεται. τοῖς γὰρ θείοις ὕδασιν ἀποπλύνοντες νῦν καὶ καλῶς οἰκονομήσαντες, πάλιν διὰ πυρὸς καὶ θείου ἀποκαθαρίσομεν, ἵνα ἀποκαλυφθῇ τὸ τῆς ☾ σῶμα, ἵνα ἴδωμεν ἡλιόδωρον [31] νεφέλην. ὦ σοφίας θεοῦ ἀνέκφραστα μυστήρια, ὦ πλουσίαι δωρεαὶ τοῖς ἠγαπηκόσι τὸν κύριον, ὦ βάθος [32] πλούτου καὶ σοφίας καὶ γνώσεως μυστηρίων. εἰ τὰ παρόντα τοιαῦτα θαυμαστὰ καὶ ἐξαίσια, ποταπὰ τὰ αἰώνια, ἃ οὐδεὶς νοῦς ἐξηγήσασθαι δύναται, εἰ τὸ ἔνυλον ἔργον ἀρρήτῳ τινὶ λόγῳ τοιοῦτον ἡμῖν φαίνεται, ποταπὰ τὰ ἀκήρατα ἀγαθὰ καὶ ἀνεξιχνίαστα κάλλη, ἃ οὐδεὶς ἰσχύει θεάσασθαι, ὑμνῶ καὶ προσκυνῶ καὶ δοξολογῶ σε, τρίας ὑπερούσιε καὶ ὑπεράγαθε καὶ ὑπέρθεε, τίς ἐξειπεῖν δύναται πρὸς ὕμνον τῶν θαυμασίων σου, ὡς ἐμεγαλύνθη. τὰ ἔργα σου, κύριε, πάντα ἐν σοφίᾳ ἐποίησας.

[25] M.—. . . . τὸ ἓν ἐπίστημον ἔργον, ...
[26] M.—ἐπυδηγηθέντες . . . .
[27] M.—ἀναπαύεται . . . .
[28] M.—ἀκμάδας.
[29] M.—ἐπὶ νω ε.
[30] M.—ὑντῶς.
[31] M.—ἡλιόθονον.
[32] M.—βάθους . . . .

perfectly fulfilled. 'For nothing is left remaining except the vapour and the raising of the water.' Having been wisely led on the path with respect to the way of the vapour, I will pursue my speech upon the raising of the water. What then is this which has been brought in? What is this raising of the water? Tell us, O guide: fulfil the gifts of thy grace. Enlighten our dim-sighted eyes, make plain the articulate substance of your doctrine, what is this raising of the water? And he is not silent on this matter: he says, the unmixed beauty does not receive into itself matter [67]. The immaterial being, it is a single composition, the good thing of a myriad names. For being of a single essence, it is reduced into itself. Around it, it extinguishes the single ray [68]. He does not wholly put in the moistening juices. For he did not perceive the loss, the life of the liquids. For he rejects the flowings of the water. For how is one to see the motion of that which does not shake off these things? Nothing is able to be filled full of it, unless first the ambient waters are drained dry from it. It is therefore needful that it should be swimming on the water, if it be not itself watery; that it may not be taught, that it may not be able, ⟨to vanish⟩ from us, that it may remain moist in a moist being. But we remove from it the embrace of the waters that we may see the great comeliness of its beauty. How shall we push it back from the participation with the waters? How shall we separate it, that there may easily be a raising of the water? There is need of panoply and courage. Who is man enough for this? Who is able to dry up the overflowing stream of waters? Who is to be found for the contest [69]? Who is ready for service? There is found a purgation of the matter, so that we may clearly see the beauty of the cloud. The same is the practical gentle coction by means of sulphur. For just as the washing with water is in the mind [61], so also is the purification of the All by sulphur [70]. For washing with the divine (sulphurous) waters now and managing the process fairly, we purify it again by fire and sulphur, that the body of the moon (*or* silver) may be revealed, that they may see the cloud the gift of the sun [71]. O unspoken mysteries of a wise God, O rich gifts to those who have loved the Lord, O depth of wealth and wisdom and gnosis of the mysteries. If the present things are such marvels and extraordinary, from what source are everlasting things which no mind is able to explain? If the material work is displayed thus to us by some unspeakable discourse, from what source are thy undefiled good and unfading beauties, which no one is capable of perceiving? I hymn and adore and glorify thee, triad superior to being, more than good and more than god. Who can speak forth to hymn thy marvels, that they may be glorified? All thy works, O Lord, thou hast made in wisdom.

Bibliography.

[1] M. Berthelot, *Origines de l'Alchimie*, Paris, 1885, xiii, 100, *et passim*.

[2] H. Kopp, *Beiträge zur Geschichte der Chimie*, pp. 437 ff.

[3] Kind, *Pauly-Wissowa. Real-Encyclopädie*, 3. A. ii, p. 2404.

[4] Bussemaker, *Revue de Philologie*, i, 1845, 415.

[5] Dietz, *Scholia in Hippocratem et Galenum*, i, 1, Preface, xix.

[6] K. Krumbacher, *Geschichte der Byzantinischen Litteratur*, 2[e] Auflage, p. 621. [Müller, *Handbuch der Klass. Alt.-Wiss.* 9, i.]

[7] Usener, *Ind. Lect. Bonn*, 1879. *De Stephano Alexandrino*, Bonn, 1880.

[8] v. Lippmann, *Entstehung und Ausbreitung der Alchimie*, ii, 204.

[9] v. Lippmann, *op. cit.*, i, 103 ff.

[10] M. Berthelot, *Collection des Anciens Alchimistes Grecs*, iii, 378 ff. This work is referred to hereafter as *Collection*.

[11] Edition of 1871, p. 354.

[12] The nature of the supposed hiatus in the MSS. of the ninth lecture of Stephanos is of importance for establishing the filiation of the MSS., and has been the subject of controversy. Berthelot, *Collection*, i, p. 179 ff.; Reitzenstein, *Zur Geschichte der Alchemie und des Mystizismus*, in the *Nachrichten der kgl. Gesellschaft der Wissenschaften zu Göttingen, Phil.-hist. Klasse*, 1919, pp. 1–37; O. Lagercrantz, *Catalogue de Manuscrits Alchimiques Grecs*, ii, 338 ff.

[13] The text of MS. Marcianus Græcus 299 (*v.* p. 118) differs in a few minor respects from that of Ideler.

[14] ἐνόλου. Not in the lexicons consulted.

[15] περιτομή. The word has almost invariably the sense of ' circumcision '.

[16] H. Kopp, *op. cit.*, p. 439, note 92, gives the title as: C. G. Gruner dissertationem inauguralem viri cl. C. G. Gesner . . . . habendam indicit. Jena, 1777.

[17] M. Berthelot, *Origines de l'Alchimie*, p. 105.

[18] I am glad to be able to express my thanks to Professor J. R. Partington for his courtesy in allowing me to consult his copy.

[19] The following works contain Pizzimenti's translation *without* the work of Stephanos:

(1) Antonii Mizaldi Monluciani Galli, Medici, Memorabilivm, sive Arcanorvm omnis generis, per Aphorismos Digestorum, Centuriæ IX. Et Democritus Abderita, De rebus Naturalibus & Mysticis. Cum Synesii, et Pelagii Commentariis. Interprete de Græca lingua, Dominico Pizimentio Vibonensi, Italo. . . . Coloniæ, Apud Joannem Birckmannum Anno D.M.LXXII.

(2) Joh. Joach. Becheri D. . . . Opuscula Chymica Rariora Addita nova Præfatione ac Indice locupletissimo multisque Figuris æneis illustrata, a Friderico Roth-Scholtzio. siles. This work contains near the end:—

Democritus Abderyta Græcus De Rebus Sacris Naturalibus et Mysticis. Cum Notis Synesii et Pelagii. Norimbergæ Apud Hæredes Joh. Dan. Tauberi, M.DCC.XVII.

(3) Fabricius Bibliothecæ Græcæ Volumen Octavum, Hamburg, MDCCXVII, contains Synesius de Arte Magna in Greek with the Latin translation of Pizimenti.

[20] See note [61].

[21] J. Ruska, *Arabische Alchemisten* (Heidelberg, 1924), i, 32 ff.

[22] Berthelot, *Origines de l'Alchimie*, p. 208.

[23] **Φύσις**, translated herein as *nature*, is the chief scientific conception of Greek Alchemy. The **φύσις** of a body is in the philosophic sense *that combination of the four elements which characterises it and gives rise to its properties.*

The notion of the natures of the metals and their interplay is found in the earliest alchemical works. Hermes is said to have written a book on *The Natures*, and in the work attributed to Isis we find allusion to this conception. In the *Physica et Mystica* of Demokritos these ideas are developed and we find the phrase, so much quoted by later authors, **Ἡ φύσις τῇ φύσει τέρπεται, καὶ ἡ φύσις τὴν φύσιν νικᾷ, καὶ ἡ φύσις τὴν φύσιν κρατεῖ**—' The Nature rejoices in the nature, the nature conquers the nature and the nature dominates the nature '. The phrase is probably later than the practical part of the work of Demokritos (Sherwood Taylor, *Ambix*, i, 1937, 38, 39) but is of considerable antiquity. Synesios attributes it to Ostanes, the reputed master of Demokritos. The introduction to the work of Isis also contains the phrase. Demokritos is also quoted as saying that ' The nature taking on the proper opposite quality becomes solid and fixed, dominating and dominated '; he also speaks of the nature of a substance being ' turned outward ' or ' turned inward '. In the alchemical works the word seems to denote very nearly what we would today call the properties of a substance. In the union of two metals, when alloyed, there might be a strife between the sets of properties of the two in which one was conquered. Thus when silver and copper were alloyed, the white ' nature ' of the silver overcame the red ' nature ' of the copper. The natures might also blend as in the making of a golden-brown alloy from copper and tin: here the nature of copper might be thought to blend with or ' rejoice in ' that of the alloying substance (*cf.* J. R. Partington, ' The Discovery of Bronze ', *Scientia*, Oct. 1936, 198). The word **φύσις** was widely applied in theology at the time of Stephanos, when controversy as to the relation of the human and divine *natures* of Christ was a burning question in Byzantium. This application of the word was probably present to the mind of Stephanos in writing these passages.

[24] **Τὸ πᾶν**: ' The All '. This phrase occurs continually in Greek Alchemy and philosophy and appears to apply to the totality of things. The assertion, **ἕν τὸ πᾶν**, found in the Chrysopœia of Kleopatra and implying a single Unity underlying all nature, is a central doctrine of Alchemy.

[25] **Ὦ ἀσώματον σῶμα . . . .**: ' O disembodied body '. The metals were said in Greek Alchemy to possess a body and soul, though it is hard to say how far this was believed to be allegorical, and how far a matter of fact. The metal itself was the living body and soul. Its apparent destruction by chemical reagents was the separation of the soul—the metallic properties—from the body, which was said to die. The metals were ' disembodied ' in a chemical reaction and their destruction, with its accompanying blackening and disintegration, was considered to be the death of the metal. The dead metal (in reality some compound) could be revivified (reduced once more to metal), whence the oft-repeated aphorism ' Unless you disembody the bodies and embody the disembodied, that which is expected will not take place '. The psychological interpretation of this is obvious and was no doubt present to the mind of Stephanos. (Note [61]).

[26] **Γένος, εἶδος**: ' genus, species '. These terms and their application in Greek Alchemy have been discussed at length by M. Stephanides (' La Naissance de la Chimie ', *Scientia*, Mar. 1922, xxxi, 189). The *genera* appear to have been metals which had a proper nature (**φύσις**), the *species* were substances such as stones, salts, etc.: they were not bodies (**σώματα**) and had no proper nature. The system is worked out in some detail by ' Philosophus Anonymus ' (VIII cent.), but his explanation of the terminology seems not altogether to tally with the usage of earliest alchemists.

[27] **Θεῖον ἄπυρρον**. This term (usually **ἄπυρον**) is used by Dioskurides and Pliny, and means ' native sulphur '. It is much used in the alchemical texts and chemical papyri and its meaning is usually as above, though its mention by Zosimos as a whitening agent may indicate orpiment.

[28] Ὠκεανίζουσα. Not in the lexicons consulted.

[29] Ἐξάρτισμα. Not in lexicons consulted. Piz. translates as *appendix*.

[30] *Id.* Χρυσόρροφον: M., Χρυσόροφον. The word appears to have the meaning *golden-roofed*. Piz. translates the passage, *O auri fluens cœlestis fons*. The word occurs again (p. 124), which seems to render improbable the conclusion that it is a copyist's error for χρυσόλοφον or χρυσοφόρον.

[31] Piz., *aureum gerens cæsariem*.

[32] The dispute as to whether it was by means of several species (εἰδη) or by one alone that the mystery was accomplished is obscurely argued in several alchemical texts, notably 'On the Assembly of the Philosophers' (Berthelot, *Collection*, ii, 35, 18) and 'That the Species is Compound and not Single and what is its Management' (*ibid.*, 272–275). The former, a fragment, attributes to The Philosopher—Demokritos—the view that a single species is employed: the latter indicates that several ingredients are required. In this passage, as in the dialogues of Kleopatra, the 'single natural ⟨thing⟩' would seem rather to be some supra-material universal entity.

[33] Ἀποθανατώσῃ. Not in lexicons consulted. Piz., . . . *ubi mortale corpus immortale reddiderit*.

[34] Μαγνησία. No concept in Alchemy is more complex than that of *Magnesia*. The word is used more than a hundred times in Greek alchemical texts, and its nature remains wholly obscure. Pliny (*H. N.*, xxxvi, 25) distinguishes five kinds of *magnes* (quoting Sotacus). They are of two kinds, 'male' and 'female'. Those of Magnesia in Macedonia are red and black, the Bœotian stones are of a reddish tint. That of the Troad is black and 'sine viribus' (destitute of attractive power). That of Magnesia in Asia is white, does not attract iron and resembles pumice. The best kinds were somewhat bluish. The Ethiopian was the best of all. These substances, with the exception of the products of the Troad and Magnesia in Asia, all appear to be magnetic oxide of iron (*v.* K. C. Bailey, *The Elder Pliny's Chapters on Chemical Subjects* (London, 1932), pp. 248–250).

The alchemical Magnesia seems to have no resemblance to Pliny's *magnes*. The substance referred to could be reduced to a metal which resembled 'molybdochalkos' (probably a lead- or antimony-copper alloy). Magnesia was to some extent volatilized by heat, for we hear of 'mercury from magnesia'. The 'body of magnesia', the metal (note [25]) obtained by its reduction, was said to be equivalent to the 'tetrasomia' or alloy of the four base metals.

All the passages referring to magnesia are exceedingly arcane and obscure; we need not suppose that all the commentators had any clear notion of its nature. Stephanos here seems to identify it with the universal nature underlying the whole universe.

[35] Χρυσοκοράλλος (χρυσοκοράλλιον). The meaning of this word is doubtful. A recipe of Demokritos (Berthelot, *Collection*, ii, 44, 4) prepares 'chrysocorallos reduced to metal'. A red gold may be intended, for its composition includes copper. Chrysocorallos itself is prepared in a very complex recipe (Berthelot, *Collection*, ii, 56, 16). It does not appear to be a metal, but a pigment or coral-like ornamental material. The sense appears to indicate a material superior to gold.

[36] Φέγγιτης. The word does not occur elsewhere in the Greek alchemical texts. In classical literature (Pliny, Suetonius) a hard stone, possibly onyx marble, seems to be intended (K. C. Bailey, *op. cit.*, p. 268). No doubt Stephanos uses the word as equivalent to 'moonstone'.

[37] The odd number, one, the natural monad, was the source of all in the Pythagorean philosophy of Stephanos. See beginning of Lecture II, p. 127, and elsewhere.

[38] Piz., *tunc seditionis certamina sedas*.

[39] The reading μεγαλία (μεγαλεία) is supported by Piz. who translates *magnalia*.

[40] Throughout the somewhat obscure passage which follows Stephanos is making the point that everything, however complex, is derived from a *single* source. All numbers are derived from the monad 1 ; all figures from the centre ; all music from the single instrument ; all light from a single light, presumably the sun. The play on μονὰς, the monad, and μένειν, to remain, is emphasized by italics.

[41] διὰ πασῶν as printed by Ideler appears to give better sense than διαπᾶσων as given by M. The passage appears to be corrupt.

[42] ληχανόντες. Not in lexicons consulted, and here taken as verb from λιχανός.

[43] Zosimos quotes this phrase as emanating from Hermes (Berthelot, *Collection*, 125, 10) :—

' For what does Hermes intend when he again prescribes that which falls from the waning of the moon, where it is found and where it is treated and how it has an unburnt nature ? '

The passage continues with a discusson of the analogy of magnesia to the moon and a comparison of its volatilization or liquefaction to the waning of the moon.

[44] Αφροσελήνον. Aphroselenon is mentioned some twenty times in the alchemical corpus. It appears to bear three senses. First is that of a soft white mineral such as selenite or mica. In this sense the word is used by Dioskurides (v. 158). Secondly it is used for a substance capable of whitening metals, perhaps arsenic trioxide obtained by sublimation (Berthelot, *Collection*, ii, 166, 7 ; 307, 14). Finally Zosimos regards it as being a compound of Aphrodite (Venus, copper) and Selene (the Moon, silver or mercury).

In this passage Stephanos is probably using the term on account of its connection with the moon and whiteness.

[45] It is uncertain whether ἐφ' ὡς is to be taken with the preceding words, as is indicated by Ideler's punctuation, or with those which follow it according to the punctuation of M.

[46] Πυρίτης. Pyrites is frequently mentioned in alchemical recipes, though it is hard to reconcile properties of the modern minerals known by that name with these. Zosimos, quoting Agathodaimon, states that ' pyrites is a general term for white and blood-coloured stones '. The Achæan and Albanian varieties are not mentioned by earlier alchemical authors.

[47] Χρυτοζώμιον, 'Liquor of Gold ', is mentioned about a dozen times in the alchemical texts. In the work of Demokritos (Berthelot, *Collection*, ii, p. 45, ll. 10, 17) it may represent (i) a yellow varnish, (ii) a liquid containing sulphides and capable of giving a golden tint to silver or other alloys (Sherwood Taylor, 'A Survey of Greek Alchemy ', *Journal of Hellenic Studies*, 1 (1930), 130).

[48] Χρυσόκοσμος. Not in lexicons consulted.

[49] Εἰσκριτήρ. Not in lexicons consulted.

[50] The formula contains two letters or symbols which do not appear to be a part of the ordinary Greek alphabet. These symbols are not included in the list given in M. and reprinted by Berthelot (*Collection*, i, 104 ff.) or by Zuretti (Alchemistica Signa, *Catalogue de Manuscrits Alchimiques Grecs*, viii, 1932). These are reproduced by Ideler by means of the Coptic letter ϥ, but the identification is doubtful.

Pizimenti omits the formula and translates ' *qui in luna videndi sensu percipitur* '.

[51] This is attributed to Agathodaimon in the text Περὶ τοῦ ὅτι ταῦτα περὶ μιᾶς βάφης ἡ τέχνη λελάληχεν. It does not seem to occur in the texts of or quotations from Demokritos. In the above text εἶτα λευκώσιν is in place of ἐφ' ὕστερον λεύκωσιν given by Stephanos. The possible chemical significance of this procedure is discussed by the writer elsewhere (Sherwood Taylor, *op. cit.*, 133, 135).

[52] *I. e.*, Demokritos.

[53] Ἰόν: *Ios*. The conception of *ios* is important in Greek Alchemy. In non-chemical works it bears the sense of *rust* or *venom*. In the chemical papyri the meaning seems to be simply '*verdigris*' or other incrustation on a corroded metal. This is also its most usual sense in alchemical texts. The removal of *ios* or cleaning of metal was termed *ἐξίωσις*. Maria and Zosimos used the term *ios* almost in the sense of *chemical compound*. The notion of the potency of the metal being present in the ios in the same way as that of the snake is in its venom seems to occur and is affirmed by the use of the word in the symbols of the Chrysopœia of Kleopatra. (Berthelot, *Collection*, i, 132, 133; Sherwood Taylor, *Ambix*, i, 43; J. R. Partington, 'The Discovery of Bronze', *Scientia*, Oct. 1936, 198.)

[54] Ῥύτιδος. Ῥυτὶς, *wrinkle*, may conceivably be an error for *ῥύσις, liquid*. Piz. translates as *sordis*. The papyrus Ebers speaks of the *wrinkled crust* (of slag or oxide) which forms on melted copper (J. R. Partington, *Origins and Development of Applied Chemistry*, p. 191).

[55] Demokritos, *Physica et Mystica*, § 29 (Berthelot, *Collection*, ii, p. 53, l. 12). The quotation is not exact. Demokritos has *ὑπολείπεται*; Stephanos, *ὑπολέλειπται*.

[56] *I. e.*, Demokritos.

[57] Κιλικίας τὸν κρόκον. The word *κρόκος, saffron*, was used in the alchemical texts in such a way as to make it probable that in many instances saffron was employed as a yellow dye liquor which was used to stain a metal, afterwards to be lacquered. The practice survived to the seventeenth century; *cf.* John Donne, *Elegie VIII*, The Comparison,

'And like vile lying stones in saffroned tinne.'

Saffron of Cilicia is mentioned by Pliny (*H. N.*, xxi, 17, 6) as the best variety.

In some passages *κρόκος* may represent a mineral (cf. *crocus martis*=ferric oxide). Demokritos in one passage says 'Saffron has the same action as the vapour'.

[58] Ἀναγαλλίδος βοτάνη. The word is usually translated 'pimpernel' (Dioskurides, ii, 209). It is mentioned, apparently as a yellow dye-plant, by Demokritos in passages from his lost works quoted by Synesios (Berthelot, *Collection*, ii, 66, 9) and Zosimos (*ibid.*, 160, 7). Its character as a dye-plant is confirmed in its mention with many such plants in a list in the work of Moses (*ibid.*, 306, 24). Synesios quotes Demokritos as speaking of 'the flower of the anagallis which has a blue flower'. Synesios had little understanding of the early technical processes of Demokritos, and explains the latter's use of the word as signifying that the water should be driven off (or distilled) (*τὸ ἀναγαγεῖν τὸ ὕδωρ*). In the *Papyrus Holmiensis* 'The juice of the anagallis which has a blue flower' is used for tinting pearls.

[59] Ῥά, rhubarb, is mentioned by Demokritos as a material for the preparation of a dye-liquor, and in fact the root has a deep yellow colour owing to the chrysarobin contained in it. The use of the material wholly puzzled Synesios, who supposed that Demokritos by the use of the phrase *τὸ πόντιον ῥᾶ* intended to draw a fanciful analogy between the river Rha flowing into the Black Sea (Πόντος) and the liquefaction of a solid.

[60] Χολῆς τετραπόδων καὶ κνωδάλων τινῶν. The gall of various creatures is frequently prescribed as a yellow colouring matter in the chemical Papyri (*P. Leyd.*, 39, 63, 74, 75. *P. Holm*, δ 2; ε 20; ζ 32; θ 11, 16, 20, 38; η 31; ξ 21; ια 41, ιδ 17) and is employed in the same fashion by Demokritos (Berthelot, *Collection*, ii, 45, 8), who in this passage mentions only calves'-bile. The work of Iamblichus, which the author has elsewhere conjectured to be a part of a hypothetical Demokritan treatise, mentions the bile of the ichneumon, fox, black-footed cock and camel. If in the time of Stephanos this work was attributed to Demokritos, the phrase 'of quadrupeds and certain beasts' would be explained. Olympiodoros (*ibid.*, 78, 18) says that Demokritos wrote on the gall of fishes.

[61] To the author's knowledge this is the earliest passage wherein it is implied that Alchemy is not a quest to be carried on in the laboratory. In this lecture Stephanos indicates clearly that he views Alchemy as a mental process (pp. 123, 131, 133). It does not of course appear from the passage whether this is Stephanos's own view of Alchemy or whether he is putting forward an earlier tradition. The latter would appear to be the more likely as Stephanos shows little evidence of original thought.

[62] This phrase does not seem to be contained in the existing work of Demokritos.

[63] **Θείου ὕδατος.** **Θεῖον ὕδωρ** may be translated as the 'divine or sulphurous water', for *θεῖον* has both meanings. This substance was the chief reagent of Greek alchemical practice. It is mentioned also in the Leyden Papyrus, 89, where it appears to be a solution of calcium polysulphide. This was probably the earliest meaning, but later the name was applied to all liquids useful in the Art, much as the modern chemist has extended the meaning of the term salt from the significance of 'common salt' to cover all similar combinations of metals and acids. It apppears to have had the power of corroding and blackening metals and of colouring them superficially: these properties are appropriate to a polysulphide solution. On the other hand the term *θεῖον ὕδωρ* was often applied to a distillate of some kind. The whole question is complex and beyond the scope of a commentary.

[64] See note [61].

[65] **Κελτικὴ νάρδος**, Celtic nard, is mentioned by Pliny and Dioskurides, and may be *Valeriana celtica.*

[66] **Βρεταννικὴ μέταλλος.** Presumably tin (Partington, *Origins and Development of Applied Chemistry*, pp. 80, 449).

[67] This phrase is not found in the existing works of Demokritos. The phrase has a Platonic ring.

[68] M. shows a stop after **αὐγὴν.** Piz., *Ipso uno nitore conquiescit. Humores autem humidam materiam reddentes non adhibet.* The notion may derive from the neo-Platonic notion of the ray of light descending from the divine and ending in matter.

[69] The whole passage is obscure. Viewed from the practical standpoint the 'raising of the waters' appears to be the evaporation of the corrosive liquid used to disintegrate the metal, so leaving a dry metallic compound. But this sense is probably not intended by Stephanos, for the whole passage is couched in terms more appropriate to the mystical Alchemy of the latest period than to the technical Alchemy of Demokritos.

[70] A 'burning of copper with sulphur' is several times described, *e. g.* by Maria (Berthelot, *Collection*, ii, 182, 6), but it does not seem to be alluded to as a purification.

[71] 'Ηλιόθονον is given in M.; *ἡλιόδωρον* by Ideler. The former word is not in the dictionaries, nor can I assign any meaning to the *-θονον* suffix: *ἡλιόθρονον*, 'seat of the sun', is a possible emendation.

REVIEWS.

A Short History of Chemistry. By J. R. PARTINGTON, M.B.E., D.Sc. Pp. xiii+386. Macmillan, 1937. 7*s.* 6*d.*

THE need for a short, balanced and authoritative history of Chemistry has long been felt; and this work, so admirably fulfilling these conditions, is sure to receive a warm welcome. The book is a scholarly production, well documented, carefully indexed and fully illustrated. It is, moreover, exceptionally free from typographical errors. On p. 22 ελεκτρος is put for ηλεκτρος: it would seem a pity to have omitted accents and breathings, even though they are indistinct in the original MS.

The preface of this work states that its intention 'is to give a concise survey of the history of Chemistry, suited to the requirements of students preparing for degree examinations'. The needs of this class of reader have therefore to some extent determined the plan of the work; for the part of the history of Chemistry with which the student of Chemistry is expected to be familiar is that which lies between the foundation of the Royal Society and the modern period, the investigations of which form the subject matter of the ordinary courses in Chemistry. It would, however, be wholly misleading to suppose that the author has not done justice to the pre-scientific period. The majority of histories of Chemistry either neglect the earliest period or give grossly erroneous accounts of it: the author, as all who are familiar with his *Origins and Development of Applied Chemistry* (reviewed in the last issue of *Ambix*) have seen for themselves, is peculiarly qualified to trace the development of Chemistry from its sources. The book opens with an admirable account of early applied Chemistry and then proceeds to give the best short description of the work of the Alexandrian chemists which has appeared in any such history. After a short but balanced survey of Arabian, mediæval and iatrochemical ideas, the author treats in considerable detail the work of J. B. van Helmont, and lays stress on the importance both of his experimental and theoretical results. The period of the foundation of modern Chemistry, from Boyle to Lavoisier, is treated with accuracy and clarity; the student should gain from this a clear idea of the various trends of that formative century and a quarter.

The later portion of the book is distinguished by its clear treatment of the history of Physical Chemistry, a matter which has been much neglected. The vast growth of Organic Chemistry is undoubtedly characteristic of the nineteenth century: it is, however, legitimate to wonder whether the future of our science will not prove the growth of Physical Chemistry to have been a portent of equal significance.

The book will be found perfectly suited to the teaching of the history of Chemistry, and will, no doubt, take its place as a standard work on the subject. [F. S. T.]

Oriental Alchemy. By MASUMI CHIKASHIGE. Pp. vii+102; 18 plates. Tokyo: Rokakuho Uchida, 1936. Price not given. Japanese edition, published 1930. *Yen* 1.50.

THIS little work cannot be regarded as a serious treatise on Alchemy: it is, none the less, worthy of notice in that it contains a good deal of information

not to be found elsewhere. The book is divided into three chapters: I, Alchemy in the East; II, Bronze Articles; III, Japanese Swords; in the last two is much interesting metallurgical material. The author has a very imperfect acquaintance with western Alchemy and history in general. The English has a faintly Oriental flavour, and it is difficult to say whether such statements as 'the time between the end of the eighteenth century and the beginning of the nineteenth century was the infancy of modern Chemistry', or 'Alchemy proper, which had culminated under the prosperous Roman Empire in the fourth century' or, in the Chronological Table, '3000 B.C. Chemistry of Egypt and Caledonia' are due to the author or the translator. It is clear, however, that the book must not be trusted outside the field of Japanese Chemistry.

The first chapter gives an account of Chinese Alchemy, illustrated by several charming plates of alchemists, and adorned by anecdotes characteristically Celestial. We learn from the work of Ko Hung that

> 'The life of a rat lasts for three hundred years, and when it has lived for one hundred years it turns white. It can divine well through a human medium. It is then called *chung*, and is able to tell anyone's fortune for the following year, and knows what is going on a thousand miles away.'

The author tries to interpret the *Hsien Yao*, or medicines of the immortals, mentioned in the *Pao Pu Tsŭ*, bestowing on the incredible accounts of them a gentle and regretful scepticism. This section will be interesting to all students of Eastern Alchemy, though no doubt they would be wise to avoid undue reliance on its statements.

Chapter II deals with receipts for bronze. Six classes of bronze are specified in the work *Chou Li K'ao Kung Chi* (The Artificers Record, the sixth part of the *Chou* Ritual), which the author attributes to the tenth century B.C. These six types of bronze contain respectively 14, 17, 20, 25, 29, and 50 per cent. of tin. The first is suitable for bells and tripod-kettles, the second for axes and hatchets, the third for halberts and trident-spears, the fourth for swords, the fifth for writing-knives and arrow-heads, the sixth for mirrors. The author shows that metals approximately of such compositions were in fact used, and that the above proportions reflect early Chinese practice except in the case of mirrors, which rarely contain more than 30 per cent. of tin.

The last chapter, on the forging of swords, is of much interest. The old swords were built up of hard steel to give a cutting edge and softer steel to give strength and toughness. Old swords are examined and their structure is illustrated.

The book, within its limitations, is a useful contribution to our knowledge of Oriental metallurgy. [F. S. T.]

THE SOCIETY FOR THE STUDY OF ALCHEMY AND EARLY CHEMISTRY.

PROGRAMME OF ORDINARY MEETINGS IN 1937–38.

Oct. 27, 1937. A. F. TITLEY, B.Sc., D.Phil.,
on
"Paracelsus: A résumé of some controversies."

Nov. 24, 1937. D J. LYSAGHT, Ph.D.,
on
"Hooke's Theory of Combustion."

Feb. 23, 1938. RICHARD B. PILCHER, O.B.E.,
on
"Alchemists' Apparatus in Art."

March 16, 1938. Professor R. CAMPBELL THOMPSON, M.A., D.Litt., F.B.A., F.S.A.,
on
"Assyrian Chemistry of the Seventh Century B.C."

May 11, 1938. Professor JOHN READ, Ph.D., M.A., Sc.D., F.R.S.,
on
"Alchemy under James IV. of Scotland."

June 29, 1938. DOROTHEA WALEY SINGER
on
"The name of Plato in Alchemy."